Lab 2: The Scientific Method

Summary

Today we will venture outside to the University pond to develop your ability to apply the scientific method to the study of animal behavior. It's not the African savannah, but given recent budget cuts, it is the best we can do. The goal of this exercise is to 1) observe animal behavior, 2) ask meaningful scientific questions relevant to animal behavior, and 3) develop hypotheses, predictions and possible methods to address the questions, hypotheses and predictions

Lab Instructions

1) Upon arriving at the pond, look around for five minutes to see what kinds of animals you can find, and which species or microhabitats interest you. Next, observe animal behavior! Choose one location with a group of animals or one specific animal and observe for 15 minutes at a time. Then, choose a new animal or group of animals at the same or at a different location and observe for 15 minutes.

2) During observations, record behaviors as objectively as possible; use your own criteria to classify behaviors, but be consistent! Try to save interpretation for later and avoid anthropomorphizing*. Use stopwatches to better quantify your observations: for instance, record times engaged in various behaviors or the time between behaviors. Remember to record the species observed, and other notes you may feel are important as to where you were making observations, and the conditions at the time.

3) After the two bouts of observations (15 minutes each), choose the set of observations that seems most interesting to you. Take ten minutes to summarize your data: for instance, construct an ethogram (that is, record the percent time engaged in various behavioral categories; see also background section below).

4) From these observations, generate at least 5 experimental questions. Think about how the four levels of analysis (that is, mechanism, development, function, and evolution) can be applied to your observations.

5) For at least three of these questions, generate hypotheses to address the question; include the null hypothesis and at least one alternative hypothesis for each question. See background section below for an explanation of these types of hypotheses.

6) For the three sets of hypotheses generated, determine at least one testable prediction (either through further observation or experimental manipulation). You should end up with two predictions – what do you predict would happen if the null hypothesis is true, and what do you predict if the alternative hypothesis is true?

*Anthropomorphizing means ascribing human characteristics to things not human, in this case non-human animals.

7) For one of your questions, think of an experimental design to test your hypothesis. Think about which of the sampling methods (see background below) would be most appropriate.

8) Turn in your work at the end of lab. You will receive participation credit for turning in the work, but we are also interested in seeing what you gained from the exercise.

Background

A) The Scientific Method

The scientific method is a process by which scientists, collectively and over time endeavor to construct an accurate representation of the world and how it functions. Standard procedures attempt to minimize experimenter bias or prejudice. The scientific method does not provide a foolproof recipe for conducing science. The doing of science also requires intelligence, imagination, and creativity.

There are 5 steps to the scientific method: (1) observation and description of phenomena; (2) formulation of a hypothesis to explain the phenomena; (3) use of the hypothesis to predict existence of other phenomena; (4) performance of experimental tests to verify the hypothesis and prediction, and if needed; (5) modification of hypotheses if predictions are clearly and repeatedly incompatible with experimental results. You will be getting practice in the first three of these steps today.

B) Observations: Ethograms

An **ethogram** is an inventory of the behavior of a species, with the behavior thoroughly described and organized into categories. An ethogram may be as simple as a list of behavioral categories observed in a species or as complex as a multi-dimensional flowchart showing what behavior gives rise to other behavior. Ethograms are useful in the preliminary stages of studies of animal behavior. They can be helpful in the design of subsequent behavioral experiments, by giving researchers a sense of what needs to be manipulated and what needs to be measured in an experiment.

In constructing an ethogram, you should define behavior in terms of the animal's actions, and not the perceived function. For example, if a kangaroo rat buries seeds, it should be recorded as “dig hole,” “drop seed,” and “cover seed.” This behavior should not be recorded as “storing food” as this is a perceived function. This interpretation is an acceptable hypothesis, but it is not in and of itself a direct observation. As objective observers, we must learn to avoid extrapolation to function or outright anthropomorphism.

Finally, an ethogram may portray the context in which behaviors are performed (for example, location, physical conditions, and occurrence of other animals, to name a few) as well as the observable consequences of a behavior (for example, what behavior follows a particular behavior, was food consumed or a predator avoided, etc.).

C) Hypotheses and Predictions

A **hypothesis** is a proposed explanation for a phenomenon. In animal behavior, it is a formally stated expectation about how a behavior operates. It must always be testable. A hypothesis is testable if and only if it can be falsified using an experimental procedure. It is important to note that although a hypothesis may be refuted, it can never be proven true beyond all doubt. At any time new data may be collected that suggests a previously accepted hypothesis does not hold true in all instances. For this reason, the statement "I have proven my hypothesis" should not be used when writing a conclusion. At best, a hypothesis is strengthened by evidence that supports it.

There are 2 types of hypotheses to be aware of: the null hypothesis and the alternative hypothesis. The **null hypothesis (H_0)** describes a default, or parsimonious state, such as outcomes determined by chance alone, while the **alternative hypothesis (H_1)** suggests a mechanism to explain a pattern or set of observations. If the alternative hypothesis explains the behavioral pattern better than the null hypothesis, the null hypothesis is rejected as an explanation for the phenomena under study. If the alternative hypothesis receives no more support than the null hypothesis, then the null hypothesis is not rejected, as it is a more parsimonious explanation for the data. It is important to note that in many experiments, there are multiple alternative hypotheses tested against the null hypothesis simultaneously, although often there is one alternative hypothesis of interest.

Predictions are clear, concise descriptions of your predicted results if a given hypothesis is the correct explanation for the phenomena of interest. If hypotheses are the 'if' in an if/then statement, then predictions are the 'then' in that statement. Predictions should always be mutually exclusive between hypotheses, meaning any two hypotheses should never share the same predictions. As such, predictions are always made before the experiment is conducted.

D) Experimental Design

Some hypotheses and their predictions can best be tested through careful observations in a natural setting, such as a correlative field study. Others such as hypotheses involving character evolution are often examined using a comparative approach across many species. However, the majority of hypotheses are tested through manipulative experiments to isolate the effects of certain causal factors. Experimenters seek to minimize confounding factors and biased observations through the use of controlled, standardized conditions.

Most experiments in biology are controlled experiments. A controlled experiment involves comparison of a control group with an experimental group. The control group and the experimental group are designed to be identical except for one factor or treatment. This factor is called the **independent variable**. During the course of a controlled experiment, a scientist observes or measures responses to the independent variables in both the control group and the experimental group. These factors are called the **dependent variable**. By convention, graphical plots of results of experiments put the independent variable on the x–axis and the dependent variable on the y–axis.

E) Sampling Methods

Behavior is recorded during preliminary observations for an experiment, and then later, during hypothesis testing. It is usually neither feasible nor necessary to record all behaviors of all animals of interest all the time. A variety of sampling methods can be used to obtain a partial record that still provides us with a valid picture of the behavior in question. In most instances, behavior can either be classified as short events (e.g. lunging at an opponent) or states lasting an appreciable time (e.g. a threat display). We can summarize the occurrence of both with counts or frequencies, while the latter can further be characterized with regard to their duration. There are a variety of ways to record behaviors during observations:

1 ***Ad Libitum Sampling***: Often abbreviated as ad lib sampling, this method records as much information as possible. It is informal, non-systematic, and often used in field notes. Ad lib sampling may sound thorough, but because the observer can never keep track of everything that is going on, the results of these observations will always be biased by the behaviors, individuals, or situations that most attract the observer's attention. It is therefore hard to derive reliable, precise and quantitative information based on these observations. Its main value is in research planning, and in studying rare but fairly obvious behaviors.

2 ***Focal Animal Sampling:*** Here, all occurrences of specified actions of one individual (the 'focal individual') are recorded during a predetermined sample period (say, ten minutes). The observer also records the length of the sample period, and the amount of time the focal animal is in view ("time in"). This method can provide unbiased data relevant to a wide variety of questions, particularly if animals remain in the field of view.

3 ***All Occurrence Sampling:*** The observer focuses on a particular behavior rather than a particular individual. For example, one might count the number of alarm calls made in a group of vervet monkeys. This is a useful method for providing the rate of occurrence of a behavior (# occurrences per unit time) or for studying the synchrony of behaviors within a group. The behavior under study should be obvious to the observer, and not so frequent that recording becomes impossible.

4 ***Instantaneous or Scan Sampling:*** An animal's activities are recorded at pre-selected moments (e.g., every 30 seconds). It is a sample of states (you are unlikely to catch an animal "in the act" of doing a behavior classified as an event), and is used to study the percent of time spent in a certain activity. If the behavior of all members of a group is surveyed within a short period of time, we call it scan sampling. This provides data on the distribution of behavioral states in a group. Instantaneous or scan sampling is best done with a sample interval as short as possible, and with behaviors that are very easily identified. The behaviors should ideally be

relatively long compared to the sample interval. It is an excellent method for collecting a lot of data on a group of animals.

E) Data Collection

Data collection, both in preliminary observations and during hypothesis testing, is the cornerstone of good science. It should be accurate, repeatable, and relevant to the question at hand. Preliminary data collection is particularly important since you will often base entire research projects from it. So always be careful and thorough. Most behavioral data collection is done digitally now days, but we are going to start with old school field notebooks. Try to include everything you can think of in your notebook (i.e. the location, species, temperature, habitat, wind speed, etc.). It is best to err on the side of caution.