Lab #11
Variability and Natural Selection in Populations of Wood Lice*

Overview

Many traits vary considerably in natural populations; other traits do not vary at all. Variation in a trait is necessary for that trait to evolve through natural selection, and the amount of variation can influence the rate at which the trait evolves. In this lab, we will measure the amount of variation in a natural population of terrestrial wood lice (Class Crustacea, Order Isopoda) and then determine which traits are subject to selection by predators by performing a simulated predation experiment.

Goals

By the end of this exercise, you should be able to:

1. Draw a frequency histogram of sampled data.
2. State and evaluate hypotheses about which traits confer a survival advantage in a simulated predation experiment.
3. Collect and record a large number of data in an organized fashion.

Means and Variation in a Population

A population of organisms almost never consists of individuals that are all exactly alike. For example, you’ve probably noticed quite a bit of variation in the size, shape, color and firmness of apples in a grocery store bin. Nevertheless, if you were to describe apples to a friend who had never seen one before, you might describe one that had a size, shape, color and firmness that were not particularly extreme but which you felt best represented apples in general. Such an apple would be an average, or mean, with respect to the particular traits you used to describe it. In biology, the mean value is useful for a number of reasons. First, it is sometimes the best representation of the population as a whole. Since classical times, naturalists have described organisms in terms of their mean characters in order to categorize them. The statement “Leopards have spots but tigers have stripes” is based on the average color patterns of these two cats and is used to classify them as separate species. Second, the mean can be used for comparing populations or samples. For instance, a plant ecologist might compare the mean heights of a shrub species living in damp and dry habitats in order to understand the species’ growth response to moisture.

But despite our tendency to think about average organisms, for some traits there remains considerable variation among individuals in a population and this variation is biologically very important. For example, the coats of some tigers are spottier than others and the coats of some leopards are more striped than others. Darwin was the first to understand the importance of such variation in organisms. He suggested that difference we observe between species (that is, their average properties) might arise from variation in those properties within species. In his words (Darwin, 1859:45),

“No one supposes that all individuals of the same species are cast in the very same mould. These individual differences are important for us, as they afford materials for natural selection to accumulate, in the same manner as man can accumulate in any given direction individual differences in his domesticated productions.”

(Here “domesticated productions” refers to the breeding of livestock for specific qualities such as egg production or docility. Such animal husbandry is an ancient practice upon which Darwin drew much of his argument for similar processes in nature).

The mean and variation of a population are easily seen by graphing the number of individuals that have a trait of a given value. Suppose you measured the sized of 10 apples and sorted the fruit into six different size classes (Table 1). You would probably find a few large apples, a few small ones, and several of intermediate size. A graph of a numbers of apples in each size class (Figure 1) is called a histogram. In this case the distribution is symmetrical (bell-shaped) and so the mean value would lie close to the middle of the histogram. The amount of variation about the mean is indicated by the breadth of the distribution.

Natural Selection

Ever since Darwin, it has been shown that variation in a trait is absolutely necessary for that trait to evolve through natural selection. Recall that natural selection is simply defined as variation in survival and reproduction that is associated with variation in a particular trait. In a study conducted by Campbell et al. (1991), *Ipomopsis aggregata* flower width varies considerably among individuals. The hummingbirds that visit these flowers remove more pollen per visit from wide flowers than from narrow flowers. Thus natural selection acting through hummingbirds on male reproductive success favors wide flowers, and one might expect the continued evolution of ever-wider flowers. There are, however, many different forms of selection in the wild. One can imagine that flower diameter might also influence female reproductive success, or the ability of a plant to survive an attack by herbivores or parasites, or its ability to synthesize sugars and grow, and so on. Furthermore, flower shape might even impose selection on hummingbird bill shape or foraging behavior. A full analysis of natural selection can be extremely complex!

Darwin proposed that over time the net effect of the various forms of selection acting on a population of organisms can result in the evolution of new species. For example, the famous Galapagos finches vary considerably in bill shape and size. This variation among species seems to have evolved in response to the distribution and abundance of different kinds of seeds among the islands of Galapagos Archipelago (Grant, 1986). Deep-billed individuals within a population survive better when they have access to large seeds, while small-billed individuals survive better when they have access to small seeds. Over time, this form of selection has resulted in different species with very different bill shapes. Presumably, the distribution and abundance of different finches has also generated complicated patterns of selection on seed size and shape, but this possibility has received less attention.

In this experiment, we will investigate 1) variation in several traits of wood lice, a common terrestrial crustacean, 2) whether and how some traits confer a survival advantage in the presence of simulated foragers and 3) whether such survival advantages depend on the kind of forager.

Pre-Experiment Observations and Questions

Obtain several wood lice from your lab instructor and observe them. Notice how they move and respond to various stimuli. Gently transfer one animal to a small petri dish lined with moist cotton. Place the lid on the dish and examine the animal with a dissecting microscope.
1. Are the isopods that were collected a random sample of those that live in the wild, or may the collector have unconsciously selected for certain traits when they caught them? If so, what traits do you think they may have selected for?

2. List 5 traits of wood lice.

3. How much variation (none, some, a lot) do you think each of the 5 traits will exhibit? Why might some traits be more variable than others?

4. What might be the relationship between the amount of variation in a trait and the intensity of selection on that trait in the past? What might be the relationship between the amount of variation and the opportunity for selection in the present?

Read the rest of the lab exercise and read the sections of your textbook that discuss evolution before you complete the following:

You will be required to measure body length, sprint speed and the number of dorsal plates of fifty wood lice. You will also choose at least one other attribute to measure. For one of the traits you will measure in the lab, state a hypothesis about whether or not it will confer a survival advantage in a simulated predation experiment. Briefly describe how you will decide whether the trait confers such an advantage.

**Materials**

<table>
<thead>
<tr>
<th>Per Group:</th>
<th>Per Lab Section:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 wood lice</td>
<td>1-2 electronic balances (mg sensitive)</td>
</tr>
<tr>
<td>50 capped vials</td>
<td>8 plastic spoons</td>
</tr>
<tr>
<td>2 rulers marked in centimeters</td>
<td>8 plastic forks</td>
</tr>
<tr>
<td>2 dissecting microscopes with lights</td>
<td>4 plastic combs</td>
</tr>
<tr>
<td>2 stopwatches</td>
<td></td>
</tr>
<tr>
<td>2 racetracks with paintbrushes</td>
<td></td>
</tr>
<tr>
<td>1 predation arena with refuges</td>
<td></td>
</tr>
<tr>
<td>2 release rings</td>
<td></td>
</tr>
<tr>
<td>2 plastic cups with lids</td>
<td></td>
</tr>
<tr>
<td>1 squirt bottle H₂O</td>
<td></td>
</tr>
<tr>
<td>10-20 small Petri dishes (35mm)</td>
<td></td>
</tr>
<tr>
<td>10-20 cotton balls</td>
<td></td>
</tr>
<tr>
<td><strong>Other Predation Tools:</strong></td>
<td></td>
</tr>
<tr>
<td>Hair combs</td>
<td></td>
</tr>
<tr>
<td>Vacuum aspirator</td>
<td></td>
</tr>
<tr>
<td>Sticky pencils</td>
<td></td>
</tr>
</tbody>
</table>

**Predation Experiment**

**A. Predator simulation**

For the first part of today’s exercise, you will be the predator on your population of prey isopods.

1. Assign one person in your group to be the artificial predator and decide which of the following tools (i.e. morphological adaptations) this predator will have: spoons, forks, or
combs. Other members of the group should be responsible for counting animals as they are caught and making sure none escape the arena.

2. Assemble the predation arena as demonstrated by your instructor. Divide your 50 isopods evenly into the two release rings at the center of the arena. Allow the animals to recover for about one minute, then when the predators are ready, release the 50 isopods simultaneously. Using only the chosen tools, the predator should pick up isopods without injuring them and place captured prey in a marked plastic cup. Collect the isopods until 25 have been captured; you may need to repeat the predation trial if many isopods escape to the refuges. Be sure to keep the victims and survivors in separate cups.

B. Measuring traits

It is most efficient to gather today’s data by having each person measure one variable and pass each animal to the next person after measuring it. Since it is difficult to mark wood lice in a manner that does not interfere with their behavior, the first person in line should transfer each animal from its holding container (labeled “victims” or “survivors”) to a clearly numbered vial after recording data on that animal. It is very important that the other students NOT know whether a given animal was a victim or survivor. Such information may bias their data unintentionally. The following measurements should be made in whatever order you think will be most efficient.

1. To measure the length of the animal, place it on cotton in a Petri dish. (Be sure that the cotton is slightly damp – not soaked!). When the dish is covered, the cotton will hold the animal in place for observation under the dissecting microscope. Measure the total length in millimeters using the ruler.

2. Count the number of dorsal plates under the microscope. If you are unfamiliar with isopod anatomy, consult the following figure.

3. Two people are needed to measure sprint speed. One person should release an animal behind the starting line of the racetrack and prod it gently with the paintbrush. As the animal crosses the starting line, the second person should start the timer. Record the time and the distance to the finish line (either 10 cm or 20 cm, depending on the individual animal). Repeat this a second time for each animal and compute the mean burst speed in cm/second. You are strongly advised to practice this procedure on non-experimental animals before actually running your tests.

4. Choose two additional characters that can be measured easily and quickly on all 50 animals.

C. Data analysis

Be sure you have data for all fifty individuals. If there was insufficient time for your group to gather these many data, obtain results from another group to pool with your own.

1. For each of the five characteristics you measured, calculate the mean and range. Enter these values at the bottom of each column of your data table.

2. Make five histograms (bar graphs), one for each characteristic measured. Be sure to label the histogram with a title and axis labels. For the x-axis, you will need to establish an appropriate number of bins, each of the same range, in which to place the values for each character. For example, for speed, you might have five bins, each with a range of 5 cm/second (0-5, 6-10, 11-15 cm/second, etc.). You may have to decide through trial and error on the number and width of the bins.

3. Evaluate your hypothesis about the survival advantage conferred by one trait of your choice by comparing the distributions of the traits in the survivors vs. the victims.
Written Summary:

1. State the hypothesis(es), and prediction(s) for the experiments. Identify the independent and dependent variables.
2. In addition to body length, sprint speed and number of dorsal plates you were asked to choose at least one other trait to measure. Describe the trait(s) that your group chose briefly explain why you chose this trait.
3. Present neatly labeled histograms (graphs). Indicate on the graph what the average value was for victims versus survivors for each parameter.
4. Briefly summarize the results by comparing the distribution of traits in survivors versus victims (for example, did the survivors tend to have a faster sprint speed than the victims?).
5. What is the relative strength of selection acting on the various traits in this simulation? What might be the consequences of these different selection intensities?
6. For those traits that were subject to selection in the simulation, why does variation in those traits persist in the wild?
7. How might a different type of predator have affected the patterns of selection on the traits you measured?
8. Attach you data sheets to the end of the written summary.

Acknowledgments

This exercise was fires designed, written and taught to students at UC Irvine by Jeffrey Kaufmann, a former graduate student in the Department of Ecology and Evolutionary Biology. Instructions that Jeff prepared have been revised and rewritten several times by Rudi Berkelhamer and, most recently, by Timothy Watkins, a current graduate student at UC Irvine. Over the years, many improvements in exercise procedures and instructions have been made as a result of helpful suggestions by both graduate teaching assistants and undergraduate students.

Literature


