POPULATION GROWTH IN DUCKWEED

Dr. Craig

PURPOSE

A fundamental property of populations is their rate of growth. We will examine population growth in a simple system, graph its progress over time, and draw conclusions about the nature of population growth.

DESCRIPTION

This investigation permits observation of population growth in a comparatively simple situation: where growth is continuous and competitors and predators are largely absent. Only the physical environment produces constraints on population growth. Population growth in this simple system should exhibit certain classic growth characteristics. Early growth should be exponential, or in other words it should occur at an increasing rate. However, as time passes, the rate of growth should slow and approach zero (i.e. the population no longer grows). Populations may even decline if the experiment runs long enough.

We will use the tiny aquatic plant Duckweed (*Lemna minor*) in this investigation because it undergoes continuous growth. In other words, it has no discreet reproductive season when periodic jumps in population size occur. Most reproduction in Duckweed is vegetative. It simply grows new leaves (called thalli) until a plant is large enough to separate into a new individual. A continuously growing plant like Duckweed exhibits well the characteristic phases of population growth.

THEORY

Early growth in small populations tends to be *exponential*. Exponential growth means that populations numbers grow at an increasing rate. Mathematically, we could write:

Populations at some point in time = starting population size raised to some power.

In symbols, we could write:

$$N_t = N_o^{\,r}$$

where is N_t is the population at time t, N_o is the starting population, and r is some power, like 2. The actual exponential equation is a bit more complex than this, but this simplified version should give you an idea of the concept. Graphically, it might look like the following:

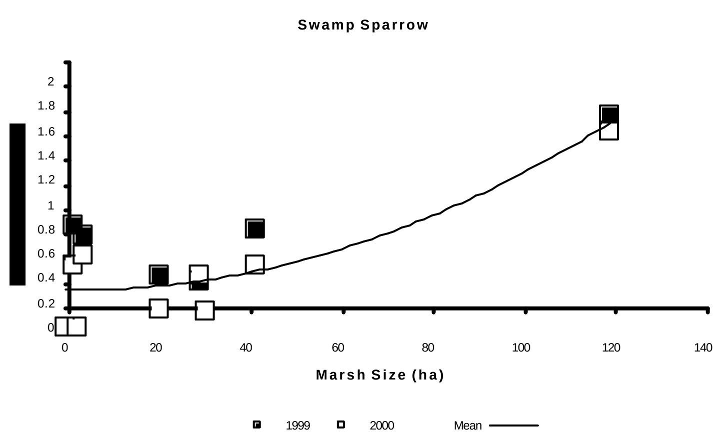

FIG. 1. Population density of Swamp Sparrows increases with habitat area.

After populations have increased to a point, crowding and food limitation become issues, and tend to slow population growth to zero. If conditions become unfavorable (what might these conditions be?), populations may decline. The slowing of population growth to zero is called *logistic growth*, and may be written mathematically as:

Population change over time = (potential for population growth x population size) / carrying capacity.

In symbols, it is written as:

$$\Delta N/\Delta t = rN(1-N/K),$$

where Δ is a symbol meaning "change in", N is population size, t is time, r is the intrinsic rate of natural increase (a measure of the potential for population growth), and K is the carrying capacity. Carrying capacity is the ability of an environment to sustain individuals in a population. As carrying capacity is approached, population growth slows. Graphically, it would appear rather like the figure below (note that the graphs reproduced here use real data, so don't conform exactly to these population models).

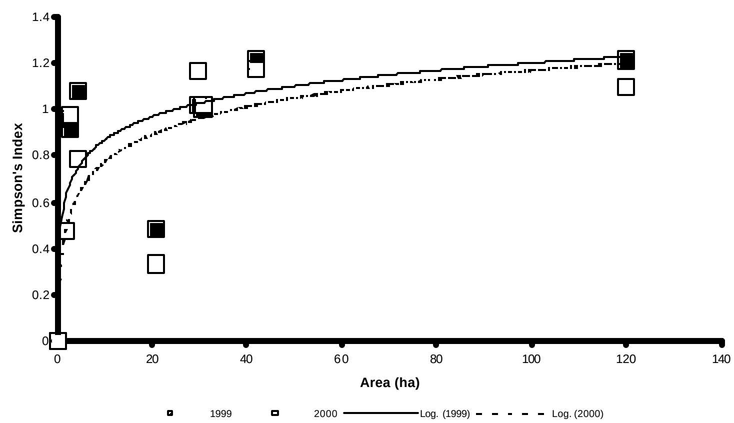

FIG. 2. Habitat area and species diversity.

Logistic growth exhibits three characteristic phases: 1) an early *lag phase*, when population growth is slow (you can see this in left side of the graph in Fig. 1), 2) a *log phase*, when population growth is rapid (see the right side of Fig. 1) , and 3) and a *steady state phase*, when population growth approaches zero (populations remain the same; see Fig. 2).

METHODS

We will begin this investigation by filling 500 ml beakers with 450 ml of strained (large algae and debris will be eliminated) pond water. Each beaker will then receive five individual Duckweed plants. On the day the study is begun, you will count the number of live leaves present on these five plants. Every second day afterwards, the number of leaves present will be counted. As needed, additional pond water will be added to the beakers to keep them at 450 ml.

You will make observations for at least four weeks. Numbers of leaves (population size) should increase rapidly at least early in the investigation. At the close of observations, the data should be plotted on a graph, with time on the x axis and number of plants on the y axis.

INTERPRETATION

Once you have prepared your graph, you must interpret what it means. The graph will have some particular shape, which will indicate that changes are occurring in rate of population growth. What are the changes, and what specifically does each change show? Interpret your graph in terms of the exponential and logistic models described above.

If you found that your data followed a logistic model (the most likely result), you can calculate fairly simply an estimate of K, the carrying capacity of the habitat (which is the 500 ml beaker).

1. The size of the available habitat is simply the surface area of the water in the beaker. Using the formula for area of a circle (if you don't remember it, look it up), calculate the total area available.
2. Now use a ruler divided into millimeters to estimate the average area of a single Duckweed leaf. To do this, line up 10 leaves in a row (you will need a forceps to line up these tiny leaves). Measure the length of this row, estimating it to the nearest tenth of a millimeter. Now divide this number by 10 to get the diameter of a single leaf (we will assume that the leaf is round). As ½ of the diameter is the radius of a circle, again use the formula for area of a circle to find the area of the leaf.
3. Divide the area of a single leaf (from 2) into the total area available (from 1) and you will have an estimate of the total number of leaves that the habitat can support. This is K.

If the experiment runs long enough, you are likely to observe a population decline. If the data show this, highlight this observation on your graph. Explain why you think a population decline has occurred. Support your explanation with a logical line of reasoning.

Make sure to compare your results with those of other lab groups. Explain in what ways your data are similar to or differ from theirs. A second graph showing both your data and theirs will be instructive, and will assist you in answering this question.