Duckweed Lab:
An Experimental Study of Population Growth

Data Calculations (3/30 or 3/31)

On 3/30 or 3/31, you will receive your group's complete data from your professor. Now, you need to estimate *K* (the carrying capacity) and calculate *r* (the intrinsic rate of increase) for each of your population.

12. *K* is estimated by averaging the last two or more counts where the population has stopped growing and leveled off. If it seems like the population has not leveled off, use the last count as *K*. Do this for each of your population and record *K* into the "Group Duckweed Data" Excel spreadsheet.
13. To calculate *r*, remember that the basic logistic population growth equation is

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

If we solve for *r*, the equation can be rewritten as

$$r = \left(\frac{dN}{dt}\right)\left(\frac{1}{N}\right)\left(\frac{K}{K-N}\right)$$

or

$$r = \left(\frac{\Delta N}{N * \Delta t}\right)\left(\frac{K}{K-N}\right)$$

Remember that $\Delta N/\Delta t$ is the change in population size (*N*) over a given time (*t*). Thus, we are multiplying it to the inverse of the population size with respect to *K*. Now, *r* can be calculated for multiple, specific time intervals and averaged (see Table 2). Below are the detailed instructions to calculate *r* for one population.

a. Using Excel or some other spreadsheet program, create a table similar to Table 2 for each of your populations. The first column should be the days we collected data. For our lab, keep in mind that we collected data every 3.5 days. To simplify the work, assume that each 3.5 day interval is one (1) day. We can make adjustments later by multiplying 1 day by 3.5.
b. *N* are the population (size) counts per day. You can copy these over from the "Group Duckweed Data" Excel Spreadsheet.
c. ΔN represents the change in population size from the previous day to the current day. You can think of this as

$$\Delta N = N_t - N_{t-1}$$

where N_t is the current day and N_{t-1} is the previous day. Enter these differences into the third column.
d. The fourth column is a division of ΔN from the third column by the product of the population from the previous day (N_{t-1}, second column) and Δt, which is 1.

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e. The fifth column incorporates the carrying capacity (K) that you averaged for the population. K is divided by the difference between K and the previous day's population size (N_{t-1}). There is no need to calculate the last row of the fifth column because this usually results in a large number, which can skew the data.

f. Finally, r (the intrinsic rate of increase, Column 6) is the product of the fourth and fifth columns. At the bottom of the column, average all the r values for the population and enter it into your "Group Duckweed Data" Excel spreadsheet.

g. Repeat this process for the rest of your group's populations.

Table 2: An example for calculating r based on the data collected, where $\Delta t = 1$ day and $K = 337$, which an average of the population size from Day 3 through Day 6.

Day	N	ΔN	$\Delta N/(N_{t-1}*\Delta t)$	$K/(K-N_{t-1})$	r
0	15	-	-	-	-
1	22	22-15=7	7/(15*1)=0.47	337/(337-15)=1.05	0.47*1.05=0.49
2	107	85	3.86	1.07	4.13
3	355	248	2.32	1.47	3.40
4	308	-47	-0.13	-18.72	2.48
5	339	31	0.10	11.62	1.17
6	346	7	0.02	-	-
			r (average)		2.33

14. Once you have recorded all of your group's populations' K and r, upload the completed file into the Group Duckweed Data link on Moodle.

Statistical Analyses (4/6 or 4/7)

Thus far, each group has uploaded their completed duckweed data onto Moodle. For statistical analyses, these data should be compiled together and reorganized. As with the previous lab, I have done the former but you have to do the latter. Before you begin, download the Class Duckweed Data Excel spreadsheet from Moodle. Also make sure that K and r were calculated correctly.

15. First, calculate the average population of all groups' Treatment 1 (all control; A, B, and C together) from the initial day.
16. Then, repeat the process for each day of Treatment 1. You should have a total of nine averages.
17. Do the same for Treatment 2 (fertilizer treatments or D, E, and F together).
18. Then, graph the growth curve of Treatment 1 and Treatment 2 using the class averages. Remember which axis the independent variable goes. The graph should have two growth curves, which are Treatment 1 and Treatment 2 averages per day.
19. Next, perform an ANOVA comparing K between the treatments and construct a graph that shows this comparison with the appropriate error bars.

20. Finally, perform an ANOVA comparing r between the treatments and construct a graph that shows this comparison with the appropriate error bars.

Specific requirements for the final paper

Introduction: Below is an outline of how the Introduction for this paper should be organized and what information should be included. Be sure to use scientific literature to support your explanations.

- Start with a paragraph that broadly explains what the experiment is about. What is the main idea of the experiment and why is it important to test? Think about the big picture of this second part of the class.
- The next paragraph should be about growth curves. Explain what growth curves are and how they relate to the main idea of the experiment.
- The third paragraph should introduce the experimental system. Why is *Lemna minor* an ideal organism for the experiment? What can it tell us about growth curves and the main idea? How might the treatments affect the growth curves?
- The last paragraph should explain how experimenting on *Lemna minor* will help us understand growth curves and the main idea (What is your objective?). Don't forget to include your biological hypothesis and make sure your references in the previous paragraphs back it up.

Results: Below is a list of specific figures that need to be included in the final paper.

- A figure showing the class average growth curves of Treatment 1 and 2.
- A figure comparing the class average of K between Treatment 1 and 2. Be sure to include the appropriate error bars that match the results of the ANOVA.
- A figure comparing the class average of r between Treatment 1 and 2. Be sure to include the appropriate error bars that match the results of the ANOVA.