Food Chain Dynamics In A Simple Ecosystem*

Overview: Food webs and trophic dynamics are important biological topics that explain community interactions, ecosystem energetics, and other ecological phenomena. Interactions among organisms in different trophic levels is a particularly important factor shaping the structure and function of communities and ecosystems. To investigate the interactions between producers and consumers, you will construct a simple ecosystem containing an algal producer and a crustacean herbivore and observe what happens over the course of a two-week period in this simple food chain. In this experiment, you will use an experimental design developed by Hudon and Finnerty (2013), but in a "flipped" format. You should first view the assigned videos that describe the fundamental features of the experimental procedure. Make notes about experimental design to investigate bottom-up or top-down effects in a simple ecosystem composed of a single producer and consumer species.

In this ecosystem study, the producer is a unicellular, marine alga in the genus (*Platymonas* sp.). This species has a flagellum which allows it to swim through its aquatic environment. The consumer is *Artemia salina* (brine shrimp), a crustacean related to crabs and lobsters. They hatch from cysts and are easily grown in lab. The larva, called a *naupilus*, are active swimmers and develop into the mature adult form in a few days. The mature adults are grazers that feed on algae.

Learning Objectives

Upon completing this laboratory exercise, students should:

- Understand the structure and function of different trophic levels in food chains.
- Understand the similarities and differences between "bottom-up" and "top-down" effects in a food chain.
- Develop skills to design, conduct, and complete an experiment with live organisms.
- Develop data collection, analysis, interpreting, and reporting skills.

Procedure

<u>Pre Lab</u>

1. View The videos Establishing An Algae-Brine Shrimp Ecosystem & Using A Spectrophotometer. Write the experimental procedure described in these videos in your notebook.
2. Complete the sample calculations in the Estimating Algae Population Sizes section (below) in your notebook.

---

*Gibson, J.P. 2018. Food change dynamics in a simple ecosystem. BIOL 1134 Spring 2018. Online Lab Exercises. Available at: [Accessed mm/dd/yyyy].

Week 1

1. In lab, you will work in groups of 4 students. Each group will conduct an ecosystem manipulation experiment manipulating either **1)** the density of algal producers or **2)** the number of herbivorous brine shrimp to the ecosystem. Groups will construct the ecosystems according to the procedures outlined in the videos.
2. Discuss the experiment you want to conduct in your group. Experiments can have either two or three replicates for a total of six jars in their experiment. Once you have decided upon the experiment you want to conduct, complete an Ecosystem Hypothesis Sheet for your GTA to review and approve. *GTA's will conduct the control conditions of jars with algae and no brine shrimp at four different concentrations (50,000 cells/ml, 100,000 cells/ml, 200,000 cells/ml, and 500,000 cells/ml). You should use one or more of three concentrations in your experiment.*
3. When your project is approved, obtain six glass jars and lids. **Using lab tape, label you jars on the lid.** Indicate group name, lab section identifier, and replicate number.
4. A brine shrimp culture was started several days ago. Obtain a small sample of brine shrimp and take them to your bench.
5. Obtain a sample of algae from the lab stock population. Using the concentration reported for the stock population, determine the amount of algae and seawater that will need to be added to achieve the desired concentrations for your experiment.
6. Once calculations for amounts of algae and seawater have been confirmed, add the appropriate volume of seawater, algae, and brine shrimp to the jars and seal.
7. The ecosystems will be placed in an illuminated incubator for one week. At the end of the experiment, you will collect your final data from the experiment.
8. Prepare tables for data collection in your notebook using the example given below in Table 1.

Week 2

1. Your GTA will bring the jars back to the lab. Get your group's jars. How do they appear? Do they look the same as they did at the beginning of the experiment?
2. Count the number of living brine shrimp in your jars. If any of them died, can you find any remnants of them such as the exoskeleton?
3. Swirl that jar to mix the algae and estimate their concentration using the spectrophotometer.
4. Record your data in your lab notebook.

Questions

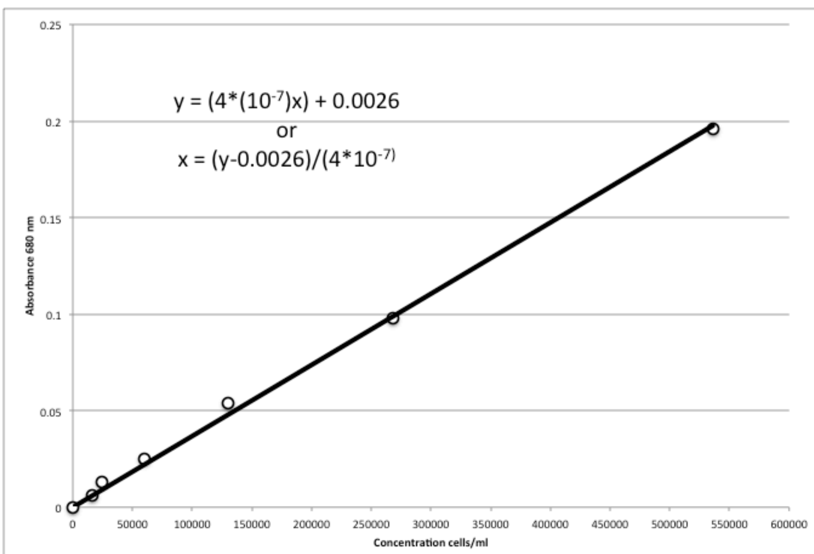
1. What central question is your experiment addressing?
2. What is the rationale for your experiment? How does your experimental manipulation test your hypothesis?
3. What to you predict will happen?

4. How should the data be analyzed? What values should you calculate and what comparisons should you make? Why?
5. How can the data be most effectively presented? Why?
6. Once you have completed the study, what experiments would you propose to do next? Why?

Calculations: Estimating Algae Population Sizes

An important component of your experiment will be to determine the size of the algal producer population in the jars. To do this, you will use a spectrophotometer to determine the density of algae in a stock population and then calculate the amount to be added to each jar to achieve a desired concentration.

Standard Curve A standard curve is a tool used in science in which the relationship between two variables has been described by a line or curve. In this example, we are using a standard curve plotting the light absorbance at a particular wavelength against a known concentration of algal cells.



To achieve a particular concentration of algae, us the formula $C_1V_1 = C_2V_2$. Multiply the desired concentration by the desired final volume. Take the product of those two values and divide by the concentration in the algae stock solution. The value from this calculation will be the amount of the algae stock solution that you need to add to an amount of seawater to give your desired total volume. For example, if you have a stock solution of 230,000 cells/ml and you want 50 ml of a 5,000 cell/ml algae solution. The calculations would be:

((5,000 cells/ml)*(50 ml))/(230,000 cells/ml) = 1.09 50 ml – 1.09 ml = 48.91 ml

Therefore, you need to add 1.09 ml of algae stock to 48.91 ml of seawater to obtain 50 ml of algae at 5,000 cells/ml.

Practice Calculations:

You are given 1L of algae and its concentration is 456,300 cells per milliliter (cell/ml) and you need a minimum concentration of 5,000 cells/ml to start with. How many milliliters of the stock would you need to add to achieve a final concentration of 10,000 cells/ml in a final volume of 50 ml of seawater? Show all work, and units.

Your lab partner takes a spectrophotometer reading at 678 nm, and records the absorbance as 0.23. Estimate the number of cells this would be equivalent to at this absorbance using the standard curve from lab.

Table 1. Example of data collection table for bring shrimp ecosystem expoeriment

Jar	Treatment	# Brine Shrimp (Pre)	# Brine Shrimp (Post)	pH (Pre)	pH (Post)	# Algae (cells/ml) (Pre)	# Algae (cells/ml) (Post)
1							
2							
Etc. . .							

References

Hudon, D. and J.R. Finnerty. 2013. To build an ecosystem: an introductory lab for environmental science and biology students. The American Biology Teacher 75:186-192.