Predator-Prey Interactions: Bean Simulation

Introduction

Interactions between predators and their prey are important in 1) determining the populations of both predators and prey, and 2) determining and maintaining the structure of a community.

Many factors enter into the ultimate outcome of predator-prey interactions. A predator must have the skills and appropriate physical structure to be able to find, recognize, capture and consume its prey. Prey try to avoid predators by employing a variety of adaptations including physical, chemical and behavioral strategies. The habitat plays an important role in determining the number of prey that can be supported, whether the predator is present or not.

In this lab exercise we will simulate a simple predator-prey interaction involving coyotes and mice.

The scenario is that a field that had once been planted in corn has now been temporarily abandoned (perhaps due to a combination of poor weather conditions, low corn prices, and the farmer's apathy). The field is now undergoing the early stages succession. Mice, as well as other herbivores, are moving into the field in search of food and shelter. As the mouse population increases, due to immigration and reproduction, coyotes and other carnivores in search of food are attracted to the area.

In this activity, the field (habitat) is represented by a shallow plate, the mouse population (prey) represented by beans, and the coyote (predator) population is presented by spoons.

Following the "rules of the community" set forth below, you will take the coyotes and mice through many generations in this field, simulating the effects of each on the population of the other over time.

Materials

- shallow plate (the field)
- beans (the mice)
- spoons (the coyotes)

Rules of the Community

1. **Initial mice population**: In each generation, there will always be <u>at least 10 mice initially present</u> in the plate. The number of mice may be higher as determined by previous generation, but can not be lower than 10. For example, if you end a generation with 4

mice, doubling its population would bring you to 8. You must add 2 so that you start the next generation with 10.

2. **Mice survival and reproduction**: At the end of each generation, the surviving mice will **double** in number, as a result of reproduction and immigration, within a range of a minimum of 10 and a maximum of 100 individuals. If the number of surviving mice at the end of a generation is so small that doubling the population still results in less than 10 mice, you must bring the number of mice back up to at least 10, as indicated in #1 above. If the number of surviving mice at the end of a generation is so large that doubling the population will result in greater than 100 mice, you must add only enough mice to the population to reach the maximum of 100, as indicated in #3 below.
3. **Mice carrying capacity:** The carrying capacity for mice in this field (plate) is 100 individuals. As indicated in #2 above, apply the doubling rule only if it does not cause the total mouse population to exceed 100. If doubling the number of surviving mice would exceed 100, add just enough mice to bring the total population up to the 100 individual maximum. Remember that this must be re-evaluated at the end of each generation.
4. **Coyote minimum population:** At the beginning of each generation there must always be at least one coyote (a spoon), presumed to have arrived there by immigration. If all of your coyotes from a given generation fail to survive, or move on, start each new generation with one coyote that has newly migrated to the area.
5. **Coyote survival and reproduction:** In order for a coyote to survive, or to decide to remain in this field, it must capture at least 5 mice (in a generation). **Failure:** If a coyote captures 4 or fewer mice, it fails to survive, or decides to move on, and will not be present at the beginning of the next generation. But remember, as indicated in #4 above, if you end a generation with zero coyotes, a new coyote will migrate into the area so that you can start the next generation with at least one coyote. **Survival:** If a coyote catches 5 or more mice in a given generation, it will survive and will be present at the beginning of the next generation. **Reproduction:** For

every 5 mice that an individual coyote catches in a given generation, the coyote will reproduce and generate 1 offspring, which will then be available at the beginning of the next generation to hunt. Each offspring will be represented by a spoon that will be available at the beginning of the next generation to participate in the hunt. For example, in a given generation, if a coyote captures 6 offspring, it will reproduce and generate 1 offspring (and two spoons will be used in the next generation, one for the surviving original coyote and one for the 1 offspring). However, if the coyote catches 11 mice it will reproduce and generate 2 offspring (and three spoons will be used in the next generation, one for the surviving original coyote and 1 for each of the 2 offspring)!

6. **Hunting:** Coyotes will hunt for mice by running through the field. We will simulate the hunt by slowly swiping a spoon across the plate one time per generation, attempting to scoop up beans (mice) (with no assistance from other hands, spoons, etc.). The number of beans scooped up in the spoon represent the number of mice caught by the coyote for that generation. For example, if a generation begins with a single coyote in the community, slowly swipe that one spoon across the plate one time and scoop up as many beans as possible, without any other assistance. If there are 2 coyotes in the population, swipe one spoon one time and then swipe a second spoon one time.

Procedure

1. Work in groups by lab table.
2. The scenarios for the first four generations are dictated below in steps 3 through 6, and the results of those generations have already been recorded in Table 1 and Table 2. Execute those dictated scenarios.
3. **Generation 1**: Begins with 10 mice in the field. Shake the plate to randomly distribute the mice. Swipe the spoon (coyote) through the field and capture 1 mouse. (Data is already recorded). Coyote does not survive, or moves on, and will not enter next generation. Surviving mouse population doubles (but can't exceed carrying capacity of 100) from 9 to 18.
4. **Generation 2**: Begins with 18 mice in the field. Shake the

plate to randomly distribute the mice. A new coyote migrates into the area, so you begin with one coyote. The coyote hunts but only captures 3 mice (data already recorded). The coyote does not survive, or moves on, and will not enter next generation. The surviving mice (15) reproduce and double their number to 30.

5. **Generation 3**: Begins with 30 mice in the field. Shake the plate to randomly distribute the mice. A new coyote migrates into the area, so you begin with one coyote. The coyote hunts and captures 6 mice (data already recorded). This coyote not only survives but has eaten enough to be able to reproduce and adds 1 offspring to the community. The surviving mice (24) reproduce and double their number to 48.
6. **Generation 4:** Begins with 48 mice in the field and two coyotes (the surviving coyote and its 1 offspring from the previous generation). Shake the plate to randomly distribute the mice. Each of the two coyotes hunt. One coyote captures 6 mice, survives, stays, and produces one offspring. The other coyote captures only 4 mice, does not survive, or moves on. The surviving mice (38) reproduce and double their number to 76.
7. **Generation 5:** Begins with 76 mice and two coyotes (two spoons). Shake the plate to randomly distribute the mice. <u>It is now time for you to take over the hunting</u>. One at a time, let each of the two coyotes hunt by swiping the spoon across the plate. Count and record the number of mice captured by each coyote. Eliminate a coyote (spoon) if it fails to catch at least 5 mice. Add a coyote offspring (spoon) for every 5 mice caught by a parent coyote. **NOTE** that any new coyote offspring (spoons) will not participate in the hunt until the next generation.
8. **Generations 6 - 20:** Repeat this process until you have results for 20 generations.
9. **Data table explanations:**
    a. **"Initial # mice"** is the number of mice that you should have at the start of each generation. It can be determined for the next generation by doubling the **"# mice surviving"** at the end of the current generation (found on third line from bottom of Table 1), unless the numbers are subject to one of the

exceptions explained in the "rules of the community".

b. **"Initial # coyotes"** is the number of coyotes that you should have at the start of each generation. It can be determined for the next generation by **"# coyote surviving"** and **"# coyote offspring"** for the current generation (found on bottom two lines of Table 1), unless the numbers are subject to one of the exceptions explained in the "rules of the community".

c. **"# of mice caught by each coyote (#1-#17)"** is the result of each coyote's hunting efforts in each generation. Space has been provided for up to 17 coyotes hunting in the community at any given time. If you need more space, add rows at the end of Table 1. You will not need all the space provided for every generation. Mark through the spaces that aren't used in a given generation (note how the spaces for coyotes 2 - 17 have been shaded out for generations 1-3 and the spaces for coyotes 3 - 17 have been shaded out for the generation 4. **NOTE**: you do not need to attempt to track the hunting efforts of a specific coyote, just based on the number of coyotes. In other words, for how ever many coyotes you have hunting during a given generation, record the results of their efforts starting in the space for coyote 1 and continuing until all coyote hunting results have been recorded.

d. **"# mice captured (S)"** is the sum of all mice captured by all coyotes during that generation. Add the numbers in the rows provided for **"# mice caught by each coyote (#1-#17)"** for the given generation.

e. **"# mice surviving"** is the number of mice remaining at the end of a generation after the coyote has hunted and captured mice. The surviving number of mice can be calculated by subtracting the **"# mice captured (S)"** from the **"Initial # mice"**.

f. **"# coyote surviving"** is the number of coyotes that survived because they successfully captured 5 or more mice. To determine this, look at the **"# of mice**

caught by each coyote (#1 - #17)" and count the number of cells which contain the number 5 or greater.

g. **"# coyote offspring"** is the number of new coyotes added to the community as a result of reproduction by existing coyotes. To determine this, look at the **"# of mice caught by each coyote (#1 - #17)"** and add 1 offspring for every 5 mice caught by each individual. For example, if 2 coyotes each caught 6 mice, you would add a total of 2 offspring, one for each of those 2 original coyotes. However, if you had 2 original coyotes and 1 coyote caught 6 mice and the other caught 13 mice, you would add 3 offspring: 1 for the coyote that caught 6 mice and 2 for the coyote that caught 13 mice.

Graph Preparation

Prepare either by hand or by computer, three graphs as indicated below. Make sure that each graph has 1) title, 2) labeled axes, 3) labeled axis units, 4) labeled/differentiated lines.

1. **Figure 1. Initial mice (m) and coyote (c) population size versus generation number.** The x-axis is generation number, the y-axis is number of individuals. This graph will have 2 lines (differentiate the lines by color, patterns or symbols); one line for the initial number of mice by generation, the other for the initial number of coyotes by generation.
2. **Figure 2. Surviving number of mice (m) and coyote (c) versus generation number.** The x-axis is generation number, the y-axis is number of individuals. This graph will have 2 lines (differentiate the lines by color, patterns or symbols); one line for the surviving number of mice by generation, the other for the surviving number of coyotes by generation.
3. **Figure 3. Number of captured mice (m) and surviving coyote (c) versus generation number.** The x-axis is generation number, the y-axis is number of individuals. This graph will have 2 lines (differentiate the lines by color, patterns or symbols); one for the number of mice captured, one for the number of surviving coyotes, both by generation.

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Submit pages 7-9

Student Name: ______________________ **Lab Date:** __________

Lab Instructor: ______________________ **Section #:** __________

Results (Data)

Table 1. Number of mice caught by coyote, summary mouse and coyote population data, for 20 generations.

- See page 9 -

Figure 1. Initial mice (m) and coyote (c) population size versus generation number.

- Attach graph -

Figure 2. Surviving number of mice (m) and coyote (c) versus generation number.

- Attach graph -

Figure 3. Number of captured mice (m) and surviving coyote (c) versus generation number.

- Attach graph -

Conclusions (Questions): *For full credit, these questions should be answered thoroughly, in complete sentences, in legible handwriting.*

1. Which population (mice or coyote) shows the first increase in numbers? Why?

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2. Describe the change in the mice population over the course of the 20 generations.

3. Describe the change in the coyote population over the course of the 20 generations.

4. Describe the relationship between changes in the mice population relative to changes in the coyote population.

5. Which of the three graphs you prepared best illustrates the relationship between changes in the mice population relative to changes in the coyote population and why?

Table 1. Number of mice caught by coyote, summary mouse & coyote population data, for 20 generations of coyote.

Generation #:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Initial # mice:		10	18	30	48	76															
Initial # coyotes:		1	1	1	2	2															
# of mice caught by each coyote (#1-#17)	1	1	3	6	6																
	2				4																
	3																				
	4																				
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	15																				
	16																				
	17																				
# mice captured (Σ)		1	3	6	10																
# mice surviving		9	15	24	38																
# coyote surviving		0	0	1	1																
# coyote offspring		0	0	1	1																