APES Predator – Prey Simulation

Objective:

You will simulate the interactions between a predator population of lynx and a prey population of rabbits in a meadow. After collecting data, you will graph it and predict populations of each for several more generations.

Introduction: Predator-prey interactions in a population are usually a feedback system. The prey population has a positive effect on the predator's numbers, but the predator population has a negative effect on the prey numbers. The predator-prey relationship can be represented as changing cyclically with a phase diagram as shown in Fig. 1 and Fig. 2.

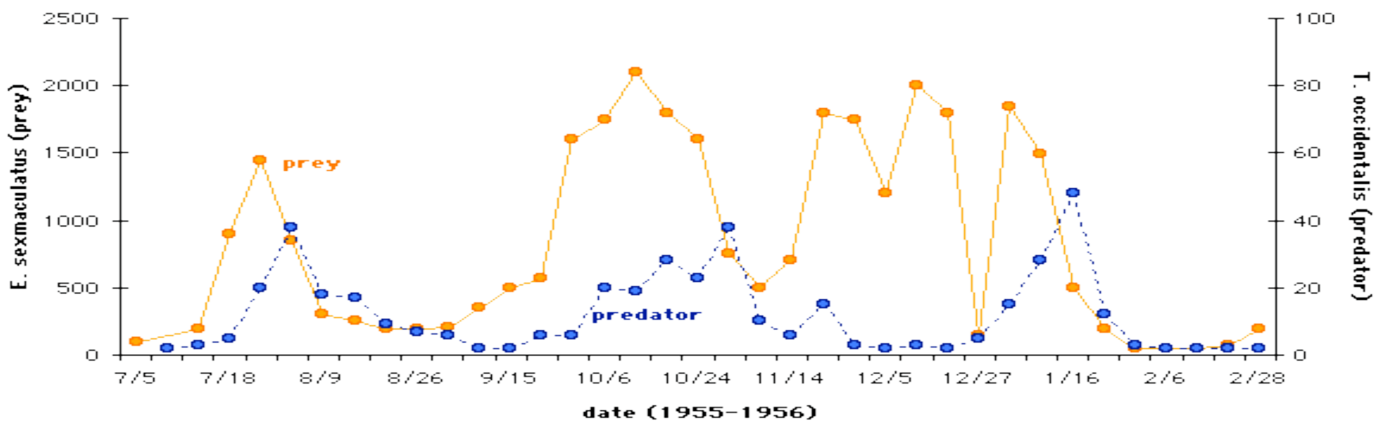

Fig. 1[1]

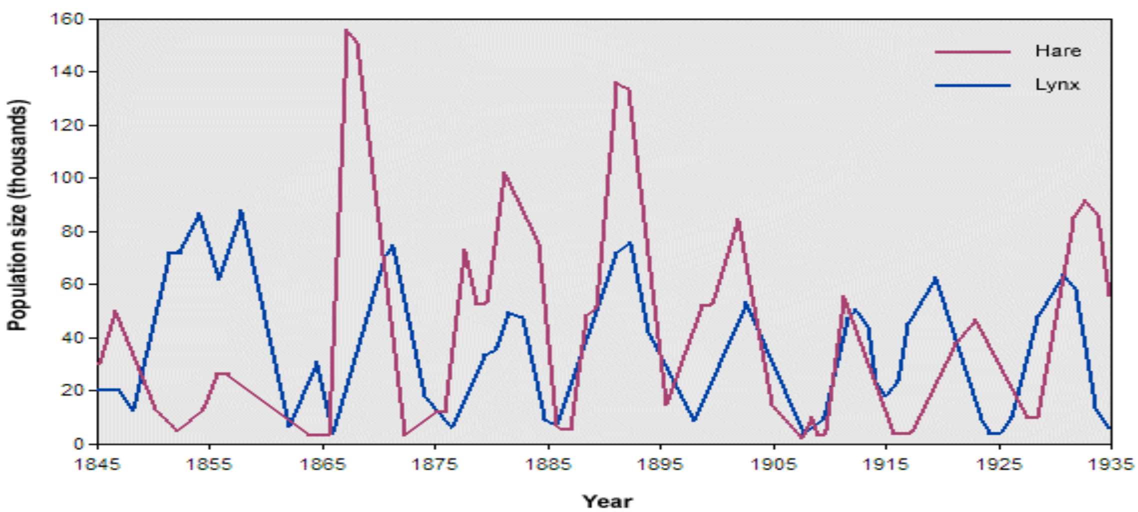

Fig. 2[2]

As the predator population rises, the prey population also rises. But as the predator numbers reach a particular value, the prey population starts to decrease followed eventually by a decrease in the predator population. In time the predator population becomes small enough for the prey numbers to rebound and the process continues into another cycle. In nature the cycles are more complex than is indicated on the two graphs above as there are many more influences on populations in the wild. In this investigation the factors will be confined simply to predator-prey numerical pressures.

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[1] Graph source: http://www.tiem.utk.edu/bioed/bealsmodules/predator-prey.html Accessed: 9/8/09

[2] Graph source: http://www.algebralab.org/practice/practice.aspx?file=Reading_PredatorPrey.xml Accessed: 9/8/09

Materials:

One 7.5cm square which will be the lynx
About 250 2.5cm squares to simulate the rabbits
A 61cm square section of table top or floor space to simulate the meadow
Masking tape to mark off the meadow
Data table
Graph paper

Procedure:

1- Distribute three rabbits to the meadow. Make sure they are spread out randomly.
2- Toss the lynx square once in an effort to catch a rabbit. The lynx needs three rabbits to survive and reproduce. The lynx is not allowed to skid on the surface.
3- Remove the rabbits that the lynx has landed on.
4- Complete the data table for the first generation. The lynx will starve and there will be no surviving lynx to reproduce this year.
5- At the beginning of the next generation, double the number of rabbits left at the end of the last generation and spread them randomly in the meadow. A new lynx immigrates into the meadow. Toss the lynx square again, removing the rabbits the lynx has landed on. Record your results for each generation.
6- Repeat step 5. Eventually the rabbit population increases to a level that allows the lynx to catch 3 rabbits in a single toss. If the lynx catches three rabbits it not only survives but reproduces too. It has one baby for each three rabbits it catches. Therefore if it catches six rabbits it will have two cubs. Lynx should try to be efficient, inefficient lynx result in an overabundance of rabbits.
7- As the number of lynx increases, throw the lynx square for each lynx in that generation. Record the number of rabbits caught by each lynx. The simulation is more realistic if the number of new baby lynx is based on each lynx's catch, not the total number caught in that generation.
8- There are always three rabbits at the beginning of a generation. If and when the rabbit population is wiped out, then new rabbits will immigrate into the meadow.
9- Model 25 generations and predict 10 more, based on the pattern observed during the first 25 generations.

Analysis:

Graph the data for your 25 generations and then extend the lines for the next ten generations. Place both the rabbit and lynx data on the same graph so that the interrelationship can be easily observed. Label the vertical axis "Number of animals and the horizontal axis "Generations". Use one color for the rabbits and another color for the lynx.

- **Note:** To monitor whether the relationship is going as expected, data can be entered directly into a spreadsheet or a graphing program as the simulation proceeds.
- If you enter data into a spreadsheet such as *Excel*, when you are ready to make a graph, highlight your data and click on the chart icon. On the chart Wizard select "Custom Types" and then scroll down to "Lines on Two Axes".
- You can also use graphing programs such as *Graphical Analysis* to monitor the data after each generation. It is possible to use graphing calculators as well, but you will need a Graphlink cable to get the data and graph into a computer so you can write up the lab.

Generation	Rabbits	Lynx	Rabbits caught	Lynx Starved	Lynx surviving	New baby lynx	Rabbits left	Total rabbits	Total lynx
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
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<u>Analysis and Problems</u>:

1. What do you predict would happen to your results if your system was disturbed by some unforeseen, outside forces? To answer parts **a** and **b**, first draw the last cycle of your experimental graph free-hand.Continue graphing for at least 3 additional cycles to display your prediction.

a. Draw on your graph and explain what would happen if some coyotes died of disease or were driven off by larger predators or hit by cars.

b. Draw on your graph and explain what would happen to the prey populations in the event of a fire, or of additional predators or another species moving in.

c. How would it matter at what point in your simulation such disturbances occur?

2. Search the Internet to find how your simulation compares to data of predator-prey systems taken from nature, such as those of owls and mice, lynx and snowshoe hare in Maine, or the moose-wolf system on Isle Royal in Michigan.

a. Look for what general pattern exists for the data from nature.

- How does the predator population vary when the prey numbers change?
- Are the populations in phase with each other?
- Are the population curves similar in shape? How do the curves differ from each other?

b. Describe how your simulation data are similar or different. If your results are different, explain why.

c. What could you do to adjust your "rules" (model) to better fit the natural patterns?

3. Compare your graphed data to the data of other groups in the class.

a. Which parameters generally made the most difference?

b. How could the initial parameters be changed to better simulate a natural system?

c. If adjustments were made to a model in the middle of the simulation, how did the data then compare to the graphs of natural data?

4. How would the graphs look different if the predator were cold-blooded? How could information on such differences be used in examining the fossil record of dinosaurs to determine if a species was warm- or cold-blooded?

5. Design a predator-prey population experiment using a planktonic rotifer, such as *Brachinus calyciflorus*, as the predator and the single-celled green algae, *Chlorella vulgaris*, as the prey. Predict what would happen to the populations if:

a. a nutrient like nitrogen were added to the water. Explain why.

b. the nitrogen levels were reduced. Explain why.

6. How could this predator-prey method be used to model the spread of a disease, such as measles, SARS, Ebola, or the swine flu, in a population center?

7. Describe at least three predator adaptations that make hunting easier. Articulate three adaptations of prey that help them escape predation.

8. Are parasites a predator? Explain.

9. In this investigation you examined only the simple relationship between changing prey populations and the number of predators. What other variables affect the number of predators and prey in a population? Describe four possible factors.

10. Describe an example of a predator being used to control a prey population that is considered a pest. Explain scientifically why you believe this is a good idea or not.

Extension There are several computer simulations of various predator=prey systems. Find one and play it.

Describe how the results of your model simulate results from computer models.