LABORATORY 44

Predator–Prey Relations

OVERVIEW

Predation, the killing and eating of one organism by another, is one of the basic mechanisms of energy flow in an ecosystem. It is also a potent selective agent, since success in obtaining prey can enhance the **fitness**—the ability to contribute genetically to the next generation—of the predator. Natural selection by predation also leads to the survival of prey individuals that possess more effective defenses such as camouflage, speed, armor, and defensive behavior. The pressures of selection lead predators to overcome the prey defenses, and thus sophisticated sensory systems, powerful attack weapons, pack hunting, and other specializations evolve. In fact, selection continues to refine the adaptations used by predators to pursue and catch prey at the same time that it leads to improved defense and escape mechanisms among the prey—a continuing evolutionary round-robin, or **coevolution.** When we examine the coadaptations of predator and prey, we expect to see adaptive solutions that hundreds of millennia of natural selection have produced.

Predation can benefit a prey population by the selective removal of excess young, older individuals less able to reproduce, and the injured and infirm—all of which require space, food, and other environmental resources. (All species possess the ability to produce far more individuals than can survive in the available space.) When humans remove natural predators such as large cats or wolves, prey populations increase to the point that habitat destruction by overgrazing reduces an area's overall **carrying capacity** (the number of individuals that can live in a given area), to the detriment of the prey population.

During this laboratory, you will use simulations to explore simple predator–prey interactions, the functional response of predators to changes in numbers of prey in a given area, and the effects of interspecific competition during predation.

STUDENT PREPARATION

Prepare for this laboratory by reading the text pages indicated by your instructor. Familiarizing yourself in advance with the information and procedures covered in this laboratory will give you a better understanding of the material and improve your efficiency.

EXERCISE A Predation

Predation is an interspecific interaction in which one population uses another as its food (energy) source—and thereby benefits—while the prey population is reduced in number. This exercise involves a simulation of simple predator–prey interactions. A simulation is a model used to represent some real-life situation that allows you to learn about the dynamics of that situation without leaving the laboratory or immediate environment. Of course, direct observations taken in the field provide a basis for more realistic and general interpretations, but time, and access to the study organisms, among other factors, make this difficult. Therefore, simulations have become widely accepted by ecologists as learning tools, provided that the model adequately reflects the natural setting. Interpretations of results obtained from models are limited by the (over)simplified conditions of the simulation, yet such models offer insights and have proven their validity as an investigative tool. Even where models have proved to be quite inadequate in the real world, they have stimulated recognition of new concepts and have led to further research.

In this simulation, you will act as the predator, foraging on stationary, nondefensive prey—macaroni. As the simulation begins, it is the beginning of "winter," which lasts 12 days. Each "day" lasts 60 seconds, and you *must* capture five prey items per day to survive. After you have captured five prey in one day, you stop hunting. If you capture less than five prey, you starve and die.

Objectives

- ☐ Explore predation on prey inhabiting a limited area that are not replaced as they are consumed.

Procedure

This experiment allows everyone in the class to contribute data to a collective pool and gain experience with the general procedure employed throughout this laboratory. It also provides baseline data with which the results from other treatments can be compared.

1. Work in pairs, with one person acting as the predator and the other serving as the timer.
2. Each pair will be assigned a 10 foot × 10 foot territory. The predator sets up a "nest" (a dish or box lid) somewhere near the middle of one of the territory edges. While the predator turns his or her back and closes his or her eyes, the timer spreads 100 food items randomly throughout the territory and then takes up a position on the side of the territory opposite the nest.
3. The predator turns around and begins looking for prey when instructed to do so by the timer. Once released to hunt, the predator captures five (and only five) prey items and returns home to the nest. As soon as the predator places the captured prey in the nest, the timer records the amount of time it took for the predator to find all of the prey on day 1. Record the data in Table 44A-1. This task *must* be completed within 60 seconds if the predator is to survive.
4. The predator and timer than initiate day 2 by repeating step 3 above (release, hunt, return to the nest with five added prey). Again, the process is timed and must be completed within 60 seconds—if the predator fails to obtain five prey items and return home within the 60-second period, it dies. In this case, record "dead" in Table 44A-1 and the simulation is over.
5. Repeat the simulation for the 12 days of winter or until the predator expires.
6. When all predators have completed this simulation, you will be assigned a new territory and you and your lab partner will switch roles.
7. Enter all class data in Table 44A-1 and compute means for each day. Use a value of 60 seconds for all dead predators. Using a separate piece of graph paper, construct a graph of your class results for predation time. Also prepare a frequency histogram (see Appendix I, Part A) of the number of surviving predators over time.

   a. *What happens as prey nearer the nest are depleted?* ________________

   As the total prey numbers are reduced? ________________

   b. *What strategy or strategies were adopted by the predator as the prey numbers declined? Does experience help make a more efficient predator?* ________________

   ____

Table 44A-1 Time Needed to Find Five Prey Items

Predator	Time (seconds) for Each Day											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean												

c. Relate your results to the natural world. Propose a natural situation that might be similar to this simulation. ____________________

____

d. What do you expect to happen to predator and prey populations as the winter progresses?

____

e. What could be added to this model to make it more realistic? ____________________

____

EXERCISE B Functional Responses by Predators

This simulation measures a predator's functional response: the way a predator's capture rate varies with changes in prey density.

Objectives

☐ Describe how predators may be affected by the density of prey.

Procedure

1. Work in pairs. This simulation is conducted just like the preceding one except that the number of prey is lower. Your instructor will give you two bags, each containing either 80, 60, or 40 prey items.
2. Move to a new 10 foot × 10 foot area. The timer should distribute prey items as in Exercise A.
3. Measure the time it takes to capture five prey. Record the data in Table 44B-1, in the appropriate section (80, 60, or 40 prey items). Continue the simulation for 12 60-second days or until the predator dies.
4. Switch roles and repeat the simulation, moving to a new 10 foot × 10 foot area.
5. Obtain data from other student pairs using the same number of prey items. Record these in the same section of Table 44B-1 and calculate means.
6. Obtain class data for other prey densities and enter these in Table 44B-1. Using a separate piece of graph paper, graph the results for each prey density on the same graph.

a. *Combining the results of Exercises A and B,* estimate *the critical prey density for your macaroni populations.*
What is the critical, minimum *number of prey needed to maintain a predator through the winter?* ____________
How did you determine this number? ____

____

b. *In a natural ecosystem, what factors would increase the critical prey density?*

____

____

Decrease the critical prey density? ____

____

It is often argued that predators control the population size of their prey species. Others argue that the prey control the size of the predator population.

c. *Using your data from Exercise B, defend one of these statements.* ____

____

d. *Does your argument agree with the trend seen in Exercise A as prey are captured and removed from the population?* ____

Table 44B-1 Time Needed to Find Five Prey Items at Various Prey Densities

80 Prey Items

Predator	Time (seconds) for Each Day											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean												

60 Prey Items

Predator	Time (seconds) for Each Day											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean												

40 Prey Items

Predator	Time (seconds) for Each Day											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean												

EXERCISE C Competition

Competition results when shared resources become limited. **Interspecific competition** involves populations of different species vying for the same food, habitat, nesting structure, or some other shared environmental resource. Interspecific competition can narrow some feature of the **niche** (the role of a species in its community) of one or more competing species. These interactions may also provide a selective force that can result in a niche shift and the evolution of distinctive morphological characteristics among competing, closely related species. **Intraspecific competition** involves individuals of the same species competing for shared resources such as access to mates or status within a social group. Intraspecific competition is usually more intense than interspecific competition because all competitors share an identical or very similar niche. (How might the niche of individuals of the same species differ? *Hint:* Consider sexual dimorphism.)

In this experiment, you will examine the potential effects of intraspecific competition on predator success, again using human predators and macaroni prey.

Objectives

☐ Investigate the potential effects of competition on predator success.

Procedure

1. Work in groups of four student pairs (eight students per group), so that there are four predators and four timers. Increase territory size to a 20 foot × 20 foot area. Timers scatter 400 prey items (100 prey items per timer) in the territory.
2. All other procedures are the same as in the previous simulations: five prey items must be captured and returned to the nest each day, a day is 60 seconds long, and winter lasts for 12 days. Failure to find five prey items causes immediate death. However, there is one additional feature to this simulation: *mild* harassment between foragers will be tolerated (four of you will be hunting at the same time and may get in each other's way or attempt to sequester particular resources). Record the times for each predator in Table 44C-1.
3. Obtain and record all class data and calculate means. Graph your results on a separate piece of graph paper.

   a. *If a predator had exclusive use of a feeding territory, would the individual be more or less likely to survive? To reproduce? Discuss.* ____________________

   ____

   b. *In what ways could a competitor affect an individual predator?* ____________________

   ____

   c. *What would be the effects of reproduction within interacting populations of prey and predators? For instance, what would happen if prey reproduced but predators did not, or vice versa? If both populations reproduced? How might these activities be interrelated and related to population numbers over time?* ____________________

   ____

   ____

Table 44C-1 Time Needed to Find Five Prey Items When Competitors Are Present

Predator	Time (seconds) for Each Day											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean												

Laboratory Review Questions and Problems

1. Compare predation and parasitism. How are they alike? How do they differ?

2. Compare predation and herbivory. How are they alike? How do they differ?

3. Develop simulations to illustrate and explore the following situations.
   a. Crypsis (camouflage provided by pattern, color, shape, behavior, etc.)

   b. Toxic prey with warning (aposematic) coloration

   c. Mimicry (fully edible prey adopt the warning coloration of a toxic model species)

   d. Alternative prey (a predator is capable of using more than one species)

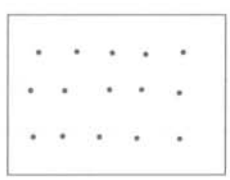
   e. Prey of different value (energy "packaged" in prey of different size)

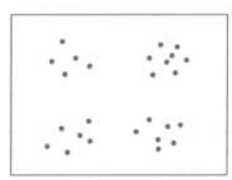
   f. Effect of prey distribution (dispersion) on hunting success (prey can be distributed randomly, evenly, or in clumped patterns)

   g. Effect of habitat complexity (one-dimensional substrate, bare, grass, forest, etc.)

4. Suppose that prey are distributed within three different territories as follows.


random


even


clumped

   a. Which type of distribution would probably allow for the highest survival of predators? Why?

b. Would it make a difference if the predator were blind (assuming the prey are stationary and give off no olfactory or auditory cues)? Why?

c. Would "learning" a pattern be advantageous? If so, which distribution(s) would allow for the highest survival of predators? Of prey?

5. Define the following terms.

Fitness

Coevolution

Niche

Interspecific competition

Intraspecific competition