Effects of Natural Selection

Lesson Plan for Secondary Science Teachers

Created by

Christine Taylor

And

Mark Urban

University of Connecticut

Department of Ecology and Evolutionary Biology

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I. **Education Standards**

This Lesson Plan meets the following National Science Education Standards:

Science as Inquiry, Content Standard **A**

Abilities necessary to do scientific inquiry: Formulate and revise scientific explanations and models using logic and evidence. In the process of answering questions, students should engage in discussions and arguments that result in the revision of their explanations. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation.

Life Science, Content Standard **C** (9 – 12):

Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.

II. Objectives

I. Students will participate in a classroom game that serves as a model of natural selection due to predator-prey dynamics.

II. Students will make predictions about how the presence of a predator will affect the traits of other organisms in a population over time.

III. Students will test their prediction using data collected from the model.

IV. Students will make conclusions about how an environment could be affected by changes in predator-prey dynamics.

V. Students will evaluate the uses and limitations of the model and make suggestions for how the model might be improved.

III. Materials

1. A large classroom space with room for students to form two "islands".
2. Printed copies of student instructions, background information and identifying tags.
3. A white board, chalkboard or SmartBoard with graphing function.

IV. Considerations

This lesson plan is designed for use in a middle or high school classroom, grades 7 - 12. The lesson in its entirety can be presented in one sixty-minute block period or in two shorter class periods. The accompanying background material will take about fifteen minutes for students to read. The game itself will take approximately 30 minutes to complete as presented, but can be shortened or lengthened by increasing the number of predators or the number of rounds that the game will continue. The lesson can be used as an introduction to a unit on evolution by natural selection or predator-prey interactions. The active, participatory nature of the game is engaging for a wide range of student ability levels and learning styles.

V. Learning Activities

The provided background information and comprehension questions will familiarize students with the three organisms that will be considered in the activity. This reading can be assigned prior to class as a homework assignment, or as a task that students can complete independently at the start of class. Teachers may assign the questions, or ask students to take notes and highlight the material. After reading the information, students should be able to explain that dytiscids prey on larger spotted salamander larvae, while marbled salamander larvae are restricted to smaller individuals.

After reading the background material and discussing the comprehension questions as a class, the students can read the description of the activity on the student handout and make their initial predictions. As a class, calculate the average height of all students in the class. This will be used to determine whether or not predation attempts were successful on each island in the simulation.

You can easily assign students to their roles and islands by handing out the provided tags. Students can use string or yarn to hang their tag around their neck, or tape the tags to their clothing. Be sure to distribute taller students and shorter students equally to both islands to avoid affecting the results of the simulation. Each island should contain one student playing the role of a predator. This student will be removing prey from the game each round to simulate predation.

Each student playing the role of a spotted salamander will have their height displayed on their tag, but should keep it concealed so that the student playing the predator role must try to assess whether or not the predation attempt will be successful based on the size of their prey. Occasionally the predator may attempt to eat a spotted salamander that is too large or too small, and the attempt will fail. While not essential for this lesson, this aspect of the game can also be used to discuss predation risks or signaling.

After each round, the students that have been removed from the group will calculate the average height of the remaining spotted salamanders on each island. If possible, these students can fill in a data table on a white board, chalkboard or SmartBoard.

When no more prey remain on an island, or the predator has failed to eat for three rounds, the game is over for that island. When the game is over on both islands, the simulation is complete. The length of the game depends on the number of prey that must be eaten before the game is over. If your class is large and you would like the game to progress more quickly or with fewer rounds, assign more than one student to each island as a predator.

Direct the students to look at the remaining players on each island and ask for a volunteer to report what they observe. Students should quickly notice that the spotted salamanders on Dytiscid Island are a shorter group than the spotted salamanders on Marbled Salamander Island. As a result, the students will be able to visualize the effect that predator-prey interactions had on the population of each island.

Students can work on the questions that accompany their student handouts. The goal of these questions is for students to explain how the predators on each island affected the population of the existing spotted salamanders on the island, and how this would also impact the traits of future generations of spotted salamanders. Since future generations are not represented in the model, students may need some guidance to make this connection.

Students are also asked to predict how these predator-prey interactions might in turn affect other species on the island. For instance, the spotted salamander itself is a predator, as described in the provided background information.

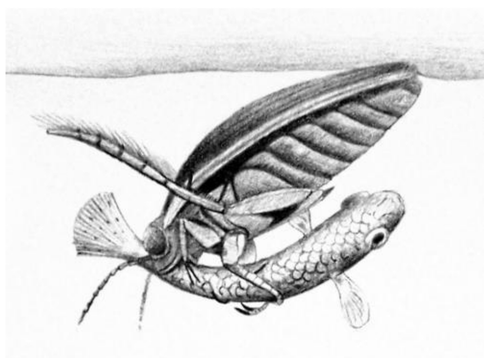
Finally, students are reminded that the game serves as a model, but it is very simplified. For instance, while natural selection due to one environmental condition, the presence of a different predator, is modeled, concepts of heredity are not included in the model. Also, in nature, it is never the case that two species exist in isolation, affecting only each other. Many species interact in a food web, and other environmental conditions aside from predation can affect the fitness of an individual. The last questions of the assignment ask students to think creatively about how the model could be improved to provide a more realistic representation of the ecosystem.

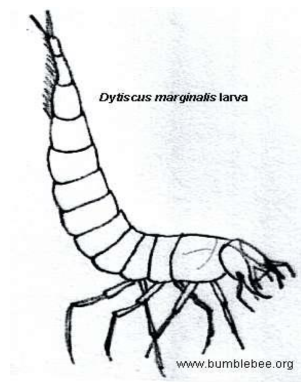
VI. Background Information for Students

In this classroom activity, the class will investigate how interactions between prey and predators can change the characteristics of a small population over time due to natural selection.

We will be studying the interactions between three organisms: the predaceous diving beetle, the spotted salamander and the marbled salamander.

The Predaceous Diving Beetle, Dytiscidae

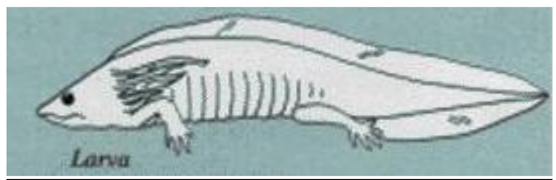




Predaceous diving beetles are a family of oval-shaped beetles that are streamlined for swimming. Adults may grow as long as two inches, and are voracious predators that will eat other insects as well as vertebrates, like tadpoles and spotted salamander larvae. They may be black or brown in color, and some species also have spots, stripes or patterns. When swimming about or hunting for prey, dytiscids keep a bubble of air under their hardened outer wings as an air supply. They must surface occasionally to obtain a new bubble of air to breathe.

As larvae, dytiscids look quite different. Instead of an oval-shaped body, they are longer and thin, with visible body segments and three pairs of segmented legs. They have a distinct head with a pair of sharp, piercing jaws called mandibles. These mandibles are hollow, and used to inject a digestive enzyme into their prey. Dytiscid larvae are such fierce predators that they are sometimes called “water tigers”. They also consume other insects and small aquatic vertebrates, like the spotted salamander larvae. They tend to prefer larger spotted salamander larvae, perhaps because they provide more food for the energy that they must expend to catch the prey.

The Marbled Salamander, *Ambystoma Opacum*



Marbled salamanders are black or gray amphibians patterned with white or grayish spots and bars, about 3 – 5 inches in length. As adults, marbled salamanders spend much of their time in underground burrows. They emerge from their burrows in late summer to breed and deposit eggs in temporary ponds that are only full for part of the year, known as vernal pools. When the vernal pools fill with water, the eggs hatch and marbled salamander larvae will emerge. These larvae will spend the winter eating insects, snails, and other small invertebrates. By spring, they will be large enough to feed on other small amphibian larvae, such as newly hatched wood frog tadpoles and other salamander larvae. Their predation of other salamander larvae, such as the spotted salamander, is limited by the size of their mouth, so they tend to prey on smaller salamanders. Marbled salamanders will undergo metamorphosis in May and June, developing two pairs of limbs. At this point, they are no longer able to breathe underwater and must dwell on land.

The Spotted Salamander, *Ambystoma Maculatum*

Spotted salamanders are larger amphibians, about 5 – 8 inches in length as adults, and are black with distinct yellow spots. They live in underground burrows or tunnels that are close to a vernal pool. When spring comes, they will migrate to the vernal pool to breed on warm, rainy nights. Females will lay eggs in a cluster called an egg mass. About 6 – 8 weeks later, the larvae will hatch. They must remain in the water at this time, and they use feathery, external gills to acquire oxygen. They feed on small invertebrates that are barely visible to the naked eye, called zooplankton, and small worms and insect larvae. As larvae, spotted salamanders are eaten by predatory insects, like the predaceous diving beetle, and by the larvae of other salamander species, such as the marbled salamander. As the vernal pools dry, the larvae will undergo metamorphosis and absorb their external gills, exiting the water as an adult.

Comprehension Questions:

1. What do dytiscid larvae eat? How do they consume their prey? What size do they prefer?

2. What do marbled salamanders eat? What size do they prefer?

3. Predict what would happen if you kept several dytiscid larvae in a tank with several spotted salamander larvae.

4. Predict what would happen if you kept several marbled and spotted salamander larvae in a tank.

5. What do you think would happen if all three organisms were kept in a tank together? Why?

VII: Student Handout

Situation:

Suppose that a biologist is studying the interactions between the predaceous diving beetle (dytiscids), spotted salamanders, and marbled salamanders. Her research sites are located on two ponds. One pond contains a population of dytiscids that she believes has an effect on the population of spotted salamanders living there. The second pond is home to a population of marbled salamanders, and she believes that this population might have an effect on the spotted salamanders living in this pond, as well.

She decides to ask a group of people to play a game that will simulate the interactions between the three organisms on the pond. This simulation will be a simple model of the predator-prey interactions at her two research sites. In the model, some participants will act as dytiscids or marbled salamanders, while others will act as spotted salamanders.

Your Task:

Your class will assist the biologist by playing the simulation game and collecting data about the results of the game. You will analyze the data that you collect and propose some possible answers to the biologist's research questions.

Rules:

- You will be assigned the role of a dytiscid, marbled salamander, or spotted salamander larva.
- In order to study how predation can affect average body size in a population, students assigned the role of a spotted salamander larva will use their height to represent the body size of a salamander. For example, if the average class height is 5'5", a 5'1" student would represent a smaller salamander, while a 5'9" student would represent a larger salamander.
- Dytiscid larvae can only prey on spotted salamander larvae that are larger than the average body size of all spotted salamanders in the class. Marbled salamander larvae can only prey on spotted salamander larvae that are smaller than or equal to the average body size of all spotted salamanders in the class.
- Pond One contains only dytiscid larvae and spotted salamander larvae, while Pond Two contains only marbled and spotted salamander larvae.
- Each round, predators will approach one spotted salamander larva and attempt to "eat" them. If the spotted salamander is eaten, that student is removed from the game.
- After each round, the class should pause the game to calculate the average body size of all spotted salamander larvae that remain in each pond.

Directions:

1. You will receive a tag that states which organism you represent and which pond you live in. Your teacher may provide you with a piece of string to wear the tag around your neck or tape to place the tag on your shirt. If you are a spotted salamander larva, write your height in the body size blank. Keep your height concealed from predators.
2. Find the other students that have been placed in your pond.
3. When the round begins, if you are a predator, approach a spotted salamander larva and announce that you will attempt to eat them. If you are a spotted salamander larva, you should reveal your height.
4. Determine whether or not the predation attempt was successful. If it was, the predator remains and the prey is removed from the game. If the attempt is unsuccessful, the predator will not eat this round. After three rounds without food, a predator will starve and be removed from the game.
5. Once you have been removed from the game, stand away from the other groups and remove your tag. You will be in charge of calculating the average height of the remaining spotted salamander larvae in each pond for the remainder of the game.
6. After each round, the students that have been removed from the game should work together to calculate the average height of the spotted salamander larvae in each pond. If available in your classroom, create a data table on the white board, chalkboard or SmartBoard.
7. The game will end when no predators remain in the ponds.
8. When the game ends, complete the provided questions on the next two pages.
9. **Before the game begins, make your predictions below:**

What will happen to the average body size (height) of spotted salamander larvae in Dytiscid Pond over time?

What will happen to the average body size (height) of spotted salamander larvae in Marbled Salamander Pond over time?

Evolution Simulation: Analysis Questions

Pond One: Dytiscid Pond

Create a graph of your results below. Label each axis and give the graph a title.

1. What is happening to the average height of the spotted salamander larvae that remain on the pond over time?

2. Explain why this is occurring.

3. What could happen to the size of new spotted salamander offspring born on the pond in future generations? Why?

4. How could other species on the pond besides the dytiscids and spotted salamanders be affected by this change?

5. Explain to the biologist how predator-prey interactions influence natural selection in Dytiscid Pond.

Pond Two: Marbled Salamander Pond

Create a graph of your results below. Label each axis and give the graph a title.

1. What is happening to the average height of the spotted salamander larvae that remain in the pond over time?

2. Explain why this is occurring.

3. What could happen to the size of new spotted salamander offspring born on the pond in future generations? Why?

4. How could other species in the pond besides the marbled and spotted salamanders be affected by this change?

5. Explain to the biologist how predator-prey interactions influence natural selection in Marbled Salamander Pond.

Understanding the Model

Models can be used to make a complex system, such as an ecosystem, easier to understand. In order to accomplish this, the model will often leave out many factors. The general idea of how the system works can be understood, but the model may not exactly represent the system as it works in nature.

1. We know that variation linked to fitness differences is one important condition for evolution by natural selection. What other condition is important? Why was this not included in our model?

2. This model represented the interactions between the larvae of predaceous diving beetles, marbled salamanders, and spotted salamanders. What other interactions may be missing from the model? Use the provided background information.

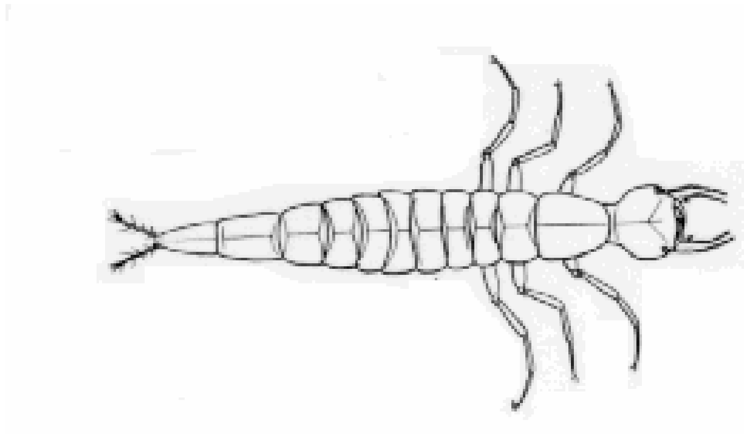
3. What other environmental conditions might cause differences between spotted salamanders in the two ponds?

4. How could the game be improved to make the model more realistic? For instance, how could you incorporate heritability, a more complete food web, or other environmental conditions? Make three suggestions.

VIII. Evolution Game Tags

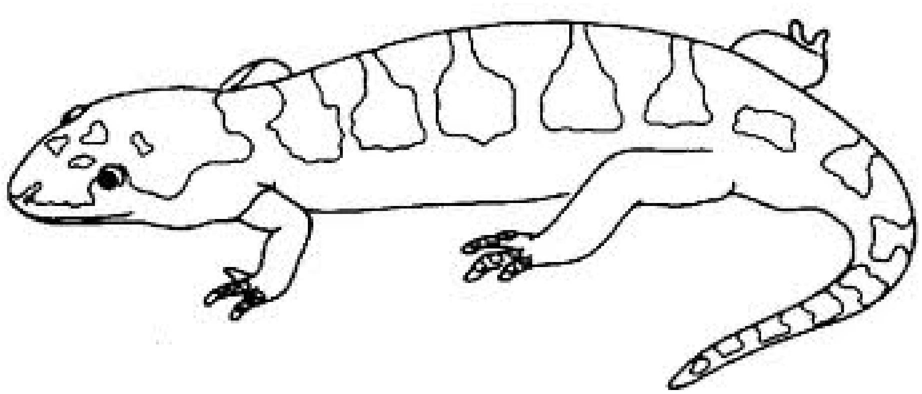
Dysticid Larva

Pond One



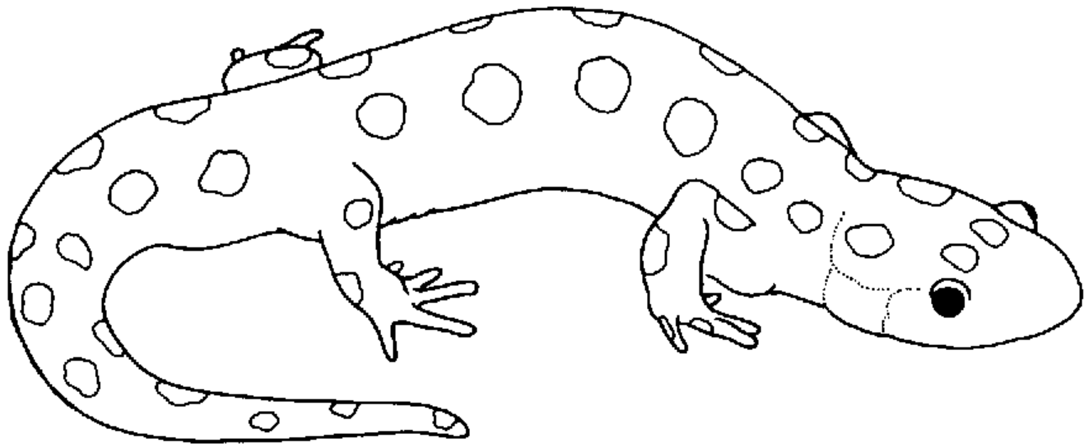
Marbled Salamander Larva

Pond Two



Spotted Salamander Larva

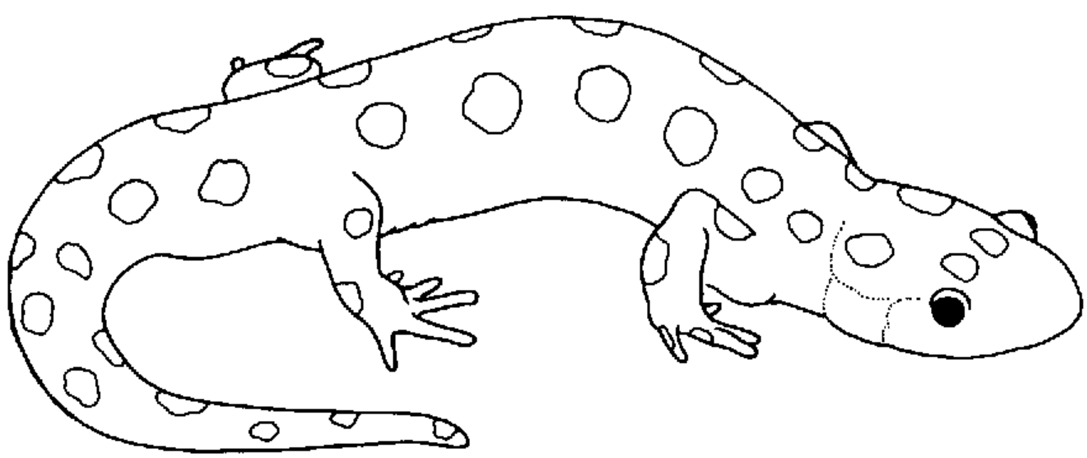
Pond One



Height: __________

Spotted Salamander Larva

Pond Two



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