Toothpick Birds
Modeling Predator Behavior in an Outdoor Lab

OBJECTIVE
Students will observe how protective coloration helps some animals to survive in nature by modeling predatory behavior while feeding on toothpick "insect" prey in an outdoor area.

LEVEL
Middle Grades: Life Science

NATIONAL STANDARDS
UCP.2, UPC4, UPC5, A1, A2, C4, C6

TEKS
6.2(B), 6.2(E), 6.3(C), 6.4(B), 6.11(A), 6.12(C)
7.2(B), 7.2(E), 7.3(C)
8.2(B), 8.2(E), 8.3(C), 8.11(A)
IPC 1(A), 2(A), 2(B), 2(C), 2(D)

CONNECTIONS TO AP
AP Biology:
- II. Heredity and Evolution: C. Evolutionary Biology 3. Mechanisms of evolution
- III. Organisms and Populations: B. Structure and Function of Plants and Animals 2. Structural, physiological, and behavioral adaptations 3. Response to the environment
- C. Ecology 1. Population dynamics 2. Communities and ecosystems

AP Environmental Science:
- II. Interdependence of Earth's Systems: Fundamental Principles and Concepts D. The Biosphere

TIME FRAME
50 minutes

MATERIALS
(For a class of 28 working individually)

- 50 uncolored wooden toothpicks
- 50 green toothpicks
- 50 yellow toothpicks
- 25 yellow with red stripe toothpicks
- whistle for teacher
- 50 red toothpicks
- 50 blue toothpicks
- watch or other timing device (for timing one minute)
- plastic cups labeled for each round of play

TEACHER NOTES

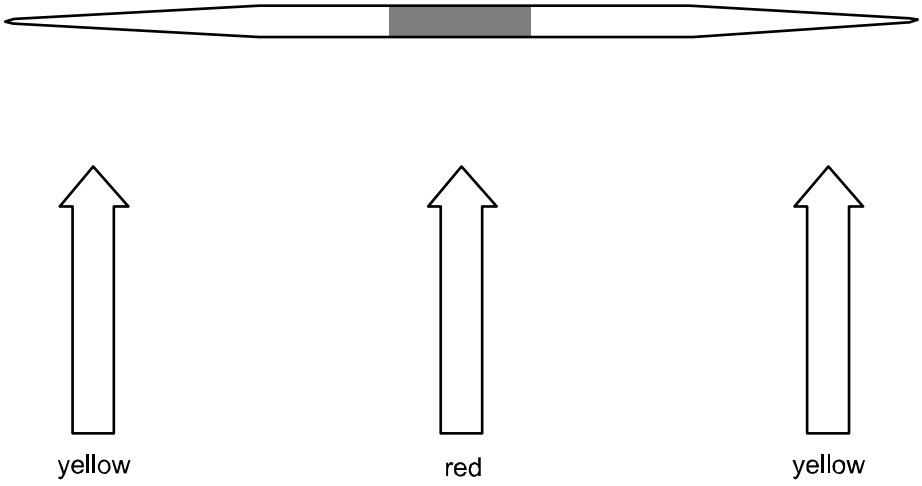
In *Toothpick Birds*, students model the behavior of a predatory bird, selecting "prey insects" (colored toothpicks) and demonstrating that protective coloration helps an organism to survive in a specified outdoor area.

The student "predators" visually attempt to feed by locating "prey" (toothpicks) in their "natural" environment. Results will differ slightly depending on the location and environment of your school. Fall, winter, or spring seasons will also affect the outcome as the toothpicks are more or less camouflaged by the changing ground colors. Ideally, this activity should be done in the spring, and the background should be mixed, some areas of dirt, some areas of green, and so on.

You will need to prepare the toothpicks in advance. A total of 275 toothpicks will need to be counted, organized and divided in the following fashion:

- 50 "wood" (natural uncolored toothpicks)
- 50 yellow
- 50 green
- 50 blue
- 50 red
- 25 yellow with a red stripe (colored by the teacher, described below)

The yellow with red stripe needs to be colored in the following fashion:



The red should be colored with a permanent red marker so the color does not bleed, especially if it is damp or wet outside. Twenty-five red with yellow stripe toothpicks are recommended because if a full total of 50 is used, all the students will notice the ones with red stripes and ask questions about them. It is up to you to decide whether or not to reveal to the students what the yellow striped toothpicks represent during the middle of the activity. Some teachers may decide to reveal what they are and some may decide to ignore the questions during the activity and address that issue once the data analysis begins back in the classroom. The yellow and red striped toothpicks have been intentionally left off the list of materials for the students so as not to spoil the discussion of the concept of mimicry.

The "wood" or uncolored toothpicks are easily found in any grocery store and one box of 500 is enough for a few years. The colored toothpicks might be a bit more difficult to locate but the colors in the box are typically the colors that are needed for this lab: yellow, blue, red, and green. It is a good idea to get two boxes of 500 to make sure that you have enough of each color for all your classes. It will take about 30-45 minutes to count, divide, and bundle the toothpicks with a rubber band into colored groups of 50 for all of your classes. All the toothpicks for each class can be put into a labeled cup or a beaker.

The "area of predation", where the modeling activity is to be performed, is generally between 100 square meters and 200 square meters. The model ecosystem can be varied according to the level of challenge for the students. Ideally, the "area of predation" will have a varying amount of background material, including grass, straw, dirt, and so on.

Before going outside to start the activity, have the students read the entire procedure so that they understand the rules. Students should then hypothesize which color will be selected the most by the "birds" and which color will be selected the least. Typically, they will choose green to be the least selected because of the camouflage effect but many times this is not the color that is selected least due to the "unnatural" shade of green dye. Usually, most or all students choose red or blue to be selected the most. Most students have a very clear idea of the concept of camouflage from previous knowledge. If you make the data table before you go outside be sure not to include the yellow with red stripe column.

To begin the activity, outline the boundaries for your students by using natural landmarks at each edge such as a tree or a sidewalk. You could also use spray paint, chalk or stakes to outline the edges of your area. Have students line up along one side of this area, facing outward. Spread all the toothpicks randomly around the "area of predation". Once toothpicks are spread, blow a whistle to signal the students to begin selecting the "prey". Allow students to "feed" for 1 minute (adjust time as needed for your students). Blow the whistle again to signal the students to stop feeding. Each student needs 4 toothpicks to survive each round. Instruct students to line up in their original starting place, along the outside of the "area of predation", again facing out. Walk by the line of students with a cup labeled "round 1", stopping at each student to collect toothpicks. "Survivors", those with 4 toothpicks, remain in position, standing on the boundary. The "non-survivors", those with less than 4 toothpicks, are directed to sit down or stand in another area, near the "area of predation" but separated from it. The survivors compete in "round 2", competing for the now decreased food source. After one minute of feeding, the survivors and non-survivors are determined and sorted as before and the toothpicks are collected in a cup labeled "round 2". Again, the same process, as described for rounds 1 and 2 is followed for rounds 3, 4 and so on until one "super predator" remains. You may choose to assign the super predator extra credit or a homework exemption or some other reward. A suggestion to allow for more rounds is to limit the number of toothpicks the students can pick up. For example, if you tell the students they can only pick up 4 toothpicks each round then there will be more food left for subsequent rounds.

Once the super predator has been determined, you can assign a few of the students to sort and count the toothpicks within the cups. Record the toothpick numbers in the data table. If time permits the entire process can be repeated, going through the rounds to select another super predator. You may or may not choose to collect data for the second scenario.

The data analysis is most efficiently done back in the classroom, away from the outside distractions. Discussion should focus on which colors were selected and which were not and why. Also, discussion of any competitive behaviors that are displayed by the students can lead to very lively discussions.

Major ecological concepts:

Mimicry: when a species mimics the traits of a poisonous species. One classic example in nature of mimicry includes the nonpoisonous viceroy butterfly mimicking the poisonous monarch butterfly. In toothpick birds, the yellow with red stripe mimics the yellow one.

Camouflage: when a species blends in to the background environment. Camouflage is probably the most well-known of animal adaptations. There are hundreds of examples in nature. Some of the most dramatic can be found in the Arthropod phylum, particularly in the order Homoptera, commonly called the leaf hopper insects, where many insects have characteristics of leaves, even down to leaf venation pattern on their wings.

Other ecological concepts that arise include natural selection and competition. You can choose how much detail to cover with the students on these topics as well. One extension to this lab activity would be to have students research other examples of mimicry in nature.

POSSIBLE ANSWERS TO THE CONCLUSION QUESTIONS AND SAMPLE DATA

Provide a data table similar to the one below on a chalkboard or overhead for students to copy. If the data table is made before the data is collected be sure to leave the yellow and red striped row off of the table.

Color of prey	R1	R2	R3	R4	R5	R6	Total selected	% Selected	Reason for Selection or non-selection
Red									
Blue									
green									
wood									
yellow									
yel/red									

Generally the toothpicks will be selected and not selected according to the following patterns.

Color of toothpick	Typical frequency of selection	Reason for selection or not
Red	High frequency of selection, typically 80-90%	"Stands out" on typically any background found outside.
Blue	High frequency of selection, typically 80-90%	"Stands out" on typically any background found outside.
Yellow	Very low degree of selection, typically 0-5%.	Poisonous.
Green	Medium frequency of selection, typically 50-60%	The green found in toothpicks is "unnaturally" green and many times will stand out. If the background is extremely green grass, then of course the degree of selection is decreased as they are more camouflaged against the green background.
Wood	Typically lower frequency of selection in a typical mixed dirt and grass environment. Typically lower selection than expected.	Camouflage.
Yellow with red stripes	Very low frequency of selection.	Mimics poisonous.

1. Which color of prey was selected more than any other color and therefore survived the least?
   - Usually red or blue is selected with the highest frequency.

2. Why was the color of prey in question #1 selected the most?
   - Red or blue is not camouflaged in any natural environment.

3. Excluding the yellow poisonous prey, which color of prey was selected least and therefore survived the most?
   - Depending on the environmental conditions, either green or wood color will usually be the colors selected the least.

4. Why was the color of prey in question #3 selected the least?
   - These colors are camouflaged in most natural environments.

5. Why didn't the predators select the yellow "insects"?
   - They are poisonous.

6. Why didn't the "birds" eat yellow-and-red-striped "insects"?
   - They mimic the poisonous prey items.

7. Which color(s) of insect is an example of camouflage?
   - Wood or green.

8. Name one example of camouflage in the natural world.
   - Accept any reasonable response. There are many well-documented examples of camouflage in nature.

9. Which color of insect is an example of mimicry?
   - The yellow with red stripe is an example of mimicry.

10. Give an example of mimicry in the natural world.
    - Accept any reasonable example of mimicry. The most common ones are probably the milk snake (non-poisonous)/coral snake (poisonous) and the viceroy butterfly (non-poisonous) and the monarch butterfly (poisonous).

11. If this simulation activity is similar to what occurs in nature, then what survival strategies are most effective in avoiding predation?
    - Camouflage and poisonous advertising.

12. Explain how, in nature, the color of an insect may determine whether it will be preyed upon or not?
    - If a prey item is able to be seen by the predator, then it has a high probability of being eaten. If it is camouflaged, there is a good chance it will not be seen and, therefore, not be eaten by the predator. If a prey item advertises its poisonous nature, and predators learn that those prey are poisonous, then they will not be eaten. The non-poisonous ones that mimic the poisonous ones are typically not eaten as well.

13. Explain how predators help to "select" which animals will survive in nature.
    - After many generations of selection, the colors that are selected and eaten with the highest frequency are eventually eliminated from the population. The color of organisms that are not selected are able to transmit their "color genes" onto the subsequent generations, causing the populations of those colors to increase.

Toothpick Birds
Modeling Predator Behavior in an Outdoor Lab

PURPOSE
In this activity you will observe how protective coloration helps some animals to survive in nature. You will model predatory behavior by feeding on toothpick prey items in an outdoor area.

Materials

wood colored toothpicks
green toothpicks
yellow toothpicks
plastic cups labeled for each round
writing utensil
red toothpicks
blue toothpicks
student instruction page
student answer page

Safety Alert
1. Be careful when picking up the toothpicks as they are sharp and can scratch and/or poke your skin.
2. Do not push, trip, tackle or engage in other horse play in the lab or during a lab outside.

PROCEDURE
1. Read through the entire procedure before beginning.

2. In the space marked HYPOTHESIS on the student answer page, formulate a hypothesis as to which "insect" will be selected the least and which one will be selected the most. The toothpick colors include wood, red, yellow, green and blue.

3. In the space marked PURPOSE on the student answer page, write the purpose of the lab.

4. In the space marked DATA TABLE on the student answer page copy the data table as your teacher instructs. You must draw the lines with a ruler or straight-edge. (R1 is an abbreviation for round one, R2 for round two, and so on…)

5. You are going to be a predatory "bird" feeding on "insects" to survive. Colored toothpicks will represent your insect prey. When instructed to begin, you will have one minute to "feed" on at least four "insects" in the feeding area outlined by your teacher. If you do not capture at least four prey toothpicks, you will die from starvation and have to sit out for the remaining rounds. After several rounds, only one "Super Predator" will survive.

Here are the rules:

- You must use your "beak" (forefinger and thumb) of one hand only.
- You may "eat" only one "insect" at a time.
- You must place the "insect" in your "crop" (your other hand) before you can reach for another insect.
- You must stop feeding when time is called. If you are reaching for an insect and your teacher has called time, do NOT finish reaching for it and stand up straight.
- You must line up along the boundary that your teacher has designated, with your back turned to the area of predation.
- Yellow "insects" are poisonous. Do not eat a yellow insect. If you accidentally pick up a yellow "insect" into your beak, put it back onto the ground. If you put the yellow insect into your "crop", then you will be poisoned and you will have to stop feeding and sit out the duration of this round.

6. After time is called for each round, put all captured insects into the plastic cup labeled, "ROUND 1". The "dead" predators will then sit in a designated area. All of the surviving birds will feed again in "ROUND 2", with each bird again eating at least 4 "insects". The eaten "insects" for Round 2 will go in the cup labeled, "ROUND 2". The class will do as many rounds as are necessary to decrease or "select" the population down to one surviving bird, the "Super Predator".

7. When there is only one "Super Predator" left, return to the room and complete your data table. Use the cups collected during each round to determine how many toothpicks of each color were consumed.

8. Use the following formula to determine the % selected for each color toothpick.

$$\%\,\text{selected} = \frac{\text{total number of a particular color collected}}{\text{number of that color of toothpick your teacher distributed}} \times 100$$

9. In the space marked EXPLANATION on your data table, provide a specific reason as to why you and the class collected the particular insects that you did. Do not state reasons that are not factual; for example, do not say that the insects tasted good since you did not really taste them.

Experiment
14

Name _____

Period _____

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PURPOSE

HYPOTHESIS

DATA TABLE

CONCLUSION QUESTIONS

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2. Why was the color of prey in question #1 selected the most?

3. Excluding the yellow poisonous prey, which color of prey was selected least and therefore survived the most?

4. Why was the color of prey in question #3 selected the least?

5. Why didn't the predators select the yellow "insects"?

6. Why didn't the "birds" eat yellow-and-red-striped "insects"?

7. Which color(s) of insect is an example of camouflage?

8. Name one example of camouflage in the natural world.

9. Which color of insect is an example of mimicry?

10. Give an example of mimicry in the natural world.

11. If this simulation activity is similar to what occurs in nature, then what survival strategies are most effective in avoiding predation?

12. Explain how, in nature, the color of an insect may determine whether it will be preyed upon or not?

13. Explain how predators help to "select" which animals will survive in nature.