Which Beak Fits the Bill? An Activity Examining Adaptation, Natural Selection and Evolution

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Abstract: Evolution is a unifying concept within biology. In fact, Dobzhansky, a noted evolutionary biologist, argued, "Nothing in biology makes sense except in the light of evolution" (Dobzhansky, 1973). However, often students have misconceptions about evolution. There are a number of available activities where students use tools (representing bird beaks) to collect different food items. These activities enable students to see how various beaks are adapted to feeding on certain types of food. This article describes an inquiry-based activity that takes the process several steps further. In this inquiry-based activity, students not only examine adaptations that birds have for capturing prey, and changes in a bird population over time, but also hypothesize what would happen to the bird population if relative seed abundances change over time. Students then model an environmental change recorded by researchers when observing Darwin's Finches. The Grant's observed a severe drought in 1977 resulting in a drastic decline in seed production with small seeds being particularly affected (Grant, 1999; Boag & Grant 1981). Students then test their hypothesis and compare their findings to those observed by the Grants. This activity is well suited for students in general biology, ecology or evolution classes.

Key words: Evolution, natural selection, adaptation, variation in populations

INTRODUCTION

Organisms display variation in traits such as body size, color, speed, and aggressiveness. Variation is found between species and within a species. Many traits of organisms are adaptations to their environment. In birds, for example, there is variability in the size and shape of the beak, or bill, which is utilized for finding and capturing food. Some birds have wide, thick bills used for crushing seeds; some have short, thin bills for picking up small prey; while others have long tubular bills for drinking nectar from flowers.

The adaptations that we see in organisms are a result of evolution by natural selection. Before conducting this activity, I introduce the concepts of adaptation, natural selection and evolution. In class, we discuss variation in bill shape and size in Darwin's finches, and how this variability arose. Then, after discussing evolution by natural selection, the students conduct this inquiry-based activity allowing them to simulate evolution.

METHODS

I divide the class into groups of 5-6 students per group. In each group, one student serves as the timer, and data recorder for the group (students can alternate jobs for Activity 2). The remaining students are "birds" and forage for seeds. Students use tweezers, pliers and other household items to simulate variation in bird beaks within a population of birds feeding on a variety of types of seeds. The "birds" each select one of five different beaks, such that in each group there are five different types of birds. I provide a range of beaks sizes to choose from. Ideas for beaks include: pointed tweezers, wide tweezers, eyelash curlers, needle nose pliers, regular pliers, forceps, snap clothespins, and different sizes of binder clips. When choosing beak types, choose a range of types including some that are very pointed, and others that are wider. This activity works best if all the pliers are spring loaded.

Each student uses their beak to forage for seeds. I explain that each student simulates a bird's beak. Students represent birds with variability in beak size and shape within a single species (for example, within one species of Darwin's finches).

First, students gain experience using their beak. I have each group assemble four stations, one for every seed type: thistle, safflower, black oil sunflower, and peanuts. Each station contains one cup of a single type of seed placed on a paper plate. Students then practice foraging at each of the stations for 1 minute (with the timer timing them). During this practice period, students use their beaks to collect as many seeds as they can from one of the foraging stations, and place the seeds in their paper cups (their stomachs). While foraging, students can only use their beaks to collect food (they cannot use their other hand to assist). They may only collect one seed at a time (they cannot grab clumps of seeds). If seeds stick to their beaks, students can tap their beak on the side of the tray to remove extra seeds. At the end of 1 minute, students count the number of seeds collected

Table 1. Number of seeds consumed by different beak types while foraging on a single seed type.

Beak Type	# Thistle Seeds	# Safflower seeds	# Sunflower seeds	# Peanut Seeds	Total # of Seeds Captured
Narrow tweezers					
Wide tweezers					
Eyelash curler					
Needle nose pliers					
Regular pliers					

and place their results in Table 1. Seeds are then placed back on the paper plate and mixed. Students then repeat the same procedure at each of the feeding stations.

Questions for students to address before they begin the next section:

1) Which seed type is each bird best at capturing? Explain why.
2) In an environment with equal quantities of the four seed types, which beak types would you hypothesize will be most abundant in the bird population? Which types would be least common? Explain why.

Activity One: Foraging in an environment with equal quantities of four different sized seeds

Next, students forage in a mixed seed patch containing equal amounts of all four seeds to test their hypothesis. Before beginning the activity, students first write down their predictions for which seed type they expect each bird to be best at collecting.

Each group of students assembles a foraging station with equal quantities (1 cup each) of the four types of seeds mixed together on a tray (e.g. pie or pizza pan). Students then use their beaks to forage for 1 minute, and record their results in an appropriately labeled table (Table 2). Students may forage for any seed type and should try to collect as many seeds as possible (as long as they only collect one seed at a time). When done, the seeds are returned to the foraging station and mixed. Each student forages twice, and calculates their averages.

Students then assess the success of each beak type. **The rules are as follows:**

1) The bird that captures the fewest total number of seeds dies (it is unable to consume sufficient energy to meet its energetic requirements). This beak type will not continue into the next generation.
2) Birds that capture between the lowest and the highest total number of seeds, survive. The next generation will begin with one of each of these beak types.
3) The bird that captures the highest total number of seeds not only lives, it produces two offspring. The next generation will begin with two additional birds of this beak type (three total).

Students compute the number of birds of each beak type that survive to the next generation, and place their results in an appropriately labeled table (Table 3). Given this new bird population, students then forage again (after replacing all seeds). At the end of 1 minute, they record their results in an appropriately labeled table (Table 2). Then, they return the seeds to the foraging station. Each student forages twice, and calculates their averages.

After calculating the average number of seeds captured, students compute the number of birds of each beak type that survive to the next generation, using the same rules as above, and place their results in Table 3.

Questions for students:

1) Given an environment with equal quantities of the four seed types, which beak types are most abundant in the bird population? Was your hypothesis supported? Which beak types are absent? Explain why.
2) If this exercise were conducted for many generations, what do you predict will happen in the population? Why?

Table 2. Number of seeds consumed by the birds during Activity (label either Activity One or Activity Two) during th generation (label either first or second generation).

Beak Type	# Thistle Seeds Trial 1	# Thistle Seeds Trial 2	Ave # of Thistle Seeds	# Safflower Seeds Trial 1	# Safflower Seeds Trial 2	Ave # of Safflower Seeds	# Sunflower Seeds Trial 1	# Sunflower Seeds Trial 2	Ave # of Sunflower Seeds	# Peanuts Trial 1	# Peanuts Trial 2	Ave # of Peanuts	Total # of Seeds Captured (Ave)
Narrow tweezers													
Wide tweezers													
Eyelash curler													
Needle nose pliers													
Regular pliers													

Each student will need four copies of this table: one for each generation of Activity One, and one for each generation of Activity Two.

Table 3. Number of birds of each beak type at the start of each generation for Activity (label either Activity One or Activity Two).

Beak Type	Parental generation	Second generation	Third generation
Narrow tweezers	1		
Wide tweezers	1		
Eyelash curler	1		
Needle nose pliers	1		
Regular pliers	1		

Part Two: Foraging after an environmental change results in unequal availability of different sized seeds

Now consider a scenario where there is an environmental change (a severe warming in the climate over several years) resulting in a drought. The drought causes a decline in seed production, particularly for small seeds. For the two largest seeds, the seed availability declines, leaving ¾ cup of each of these seed types in the environment. For the two smallest seeds, the seed availability declines to a greater extent, resulting in 1/8 cup of each of these seed types in the environment. This situation is analogous to the environmental change noticed by Peter and Rosemary Grant while researching Darwin's Finches. The Grant's observed a severe drought in 1977 resulting in a drastic decline in seed production with small seeds being particularly affected (Grant, 1999; Boag & Grant 1981).

Each group of students next establishes a feeding station representing the new environment (¾ c each of sunflower seeds and peanuts, mixed with 1/8 c each of thistle and safflower seeds on a tray). Before beginning the activity, students record their hypothesis regarding which birds will be best at surviving and reproducing.

Questions for students to address before they start the next section:

1) In an environment with greater availability of large seed types, which beak types do you hypothesize will be most common in the population? Which beak types would be least common? Explain why.

As in Activity 1, students use their bills (starting with one student representing each of the 5 beak types) to forage for 1 minute and collect as many seeds as possible. Each student forages twice, calculates their averages, and places their results in a labeled table (Table 2). After computing the average number of seeds captured, students then assess the success of each beak type using the same rules as before. Students compute the number of birds of each beak type that survive to the next generation, and place their results in an appropriately labeled table (Table 3). Given this new bird population, students then forage again (after replacing all seeds). Each student forages twice, and records their averages (Table 2). Students then assess the success of each beak, and compute the number of birds of each beak type that survive to the next generation (Table 3).

Questions for students:

1) Given an environment with unequal quantities of the four seed types (with a greater abundance of large seeds), which beak types are most common in the population after several generations? Why? Was your hypothesis supported?
2) If this exercise were conducted for many generations, what do you predict will happen? Why?
3) How do the results from Activity Two compare to the results from Activity One? Are they different? If so, explain why.
4) Obtain a copy of the article by Boag and Grant (1981). They found that as a result of the drought, birds (especially small finches) suffered high mortality, resulting in a change in average bill depth. How do your results compare to those observed by Boag and Grant? Explain similarities and differences.

Safety Considerations

Students should wear safety glasses when conducting these exercises. Students should also be instructed to only use the tools for picking up seeds and to never point them towards other students.

DISCUSSION

This exercise provides an opportunity for students to simulate evolution via natural selection in a population. By actively simulating how populations evolve over time, students gain a better understanding of the process of evolution by natural selection. Students get to examine how traits that improve an individual's survival and reproduction increase in a population, and how those traits that reduce an individual's survival and reproduction decrease in a population.

REFERENCES

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