

Evolution in Action: Data Analysis

INTRODUCTION

How and why do species change over time? In this activity, you'll explore real data that scientists collected to investigate this question. These data were taken from a population of birds called **finches**, before and after a drought in the Galápagos Islands.

In Part 1, you'll watch a short film to learn more about the finches and the scientists who studied them: Peter and Rosemary Grant. In Part 2, you'll interpret the Grants' data and suggest hypotheses to explain their observations. In Part 3, you'll explore the reason why the Grants collected data on so many birds. Finally, in Part 4, you'll use the data to make graphs and propose how and why some characteristics are more likely than others to change from one generation to the next. The concepts you'll learn apply not only to finches in the Galápagos but also to any organism in any environment.

MATERIALS

- the finch data set (in [Data Explorer](#) or as a spreadsheet)
- access to *Data Explorer* or a spreadsheet program
- (optional) calculator and graphing materials (colored pencils, rulers, graph paper, etc.)

PART 1: Introducing the Study

In 1973, biologists Peter and Rosemary Grant began observing finches on several islands in the Galápagos. They wanted to understand how changes in the environment can influence a species' physical characteristics.

As part of their work, the Grants studied the population of medium ground finches (Figure 1) on the island of Daphne Major. Every year for 40 years, the Grants measured several physical characteristics — including wing length, body mass, and beak depth — of hundreds of medium ground finches. They focused on these characteristics because they vary widely among individual birds within the same species. Small differences in these characteristics can also be important for survival in different environments.



Figure 1. A medium ground finch (*Geospiza fortis*), one of the finch species on Daphne Major.

Watch the short film [The Beak of the Finch](#) to learn more about the Grants' research and some of their findings. Answer the following questions based on what you learned.

1. Describe the major environmental change on Daphne Major that took place in 1977.
2. What types of medium ground finches were *more* likely to survive the environmental change you described?

PART 2: Analyzing Data with Histograms

You will now explore one of the Grants' data sets. Open the finch data set. In [Data Explorer](#), you can do this by clicking "Choose data to explore" on the landing page, selecting the "Finches in the Galápagos" data set, and then clicking the "Data" tab at the top.

This data set contains measurements from 100 medium ground finches on Daphne Major, all born between 1973 and 1976. The 50 finches labeled as nonsurvivors did not survive the drought and died in 1977. The 50 finches labeled as survivors survived the drought and were still alive in 1978.

While exploring the data set, you may notice some differences between the nonsurvivors and survivors. These differences may have involved **beak depth**, which is a measure of beak size (Figure 2).

One way to visualize the differences is to graph the data. Figure 3 shows graphs of beak depth measurements for the nonsurvivors and survivors. These types of graphs, called **histograms**, show the distribution of measurements — that is, the values that were measured and how often they occurred.

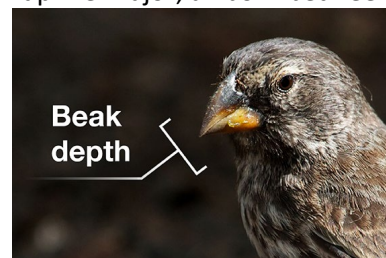


Figure 2. A diagram showing how beak depth is measured.

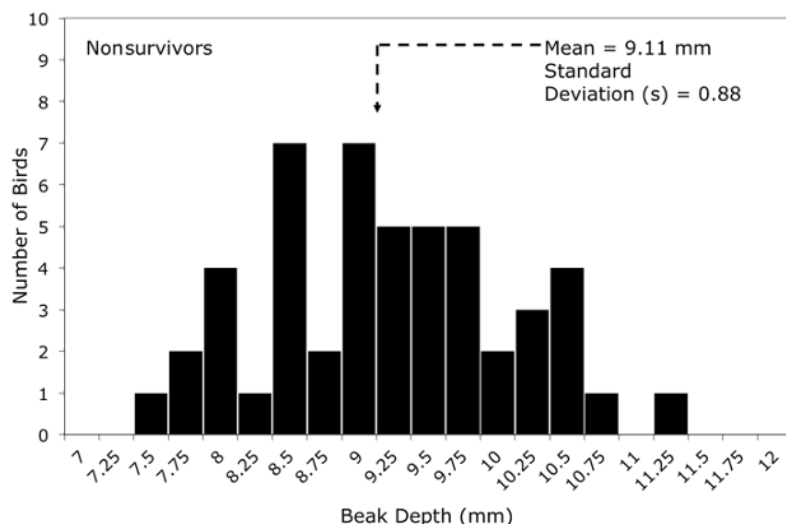
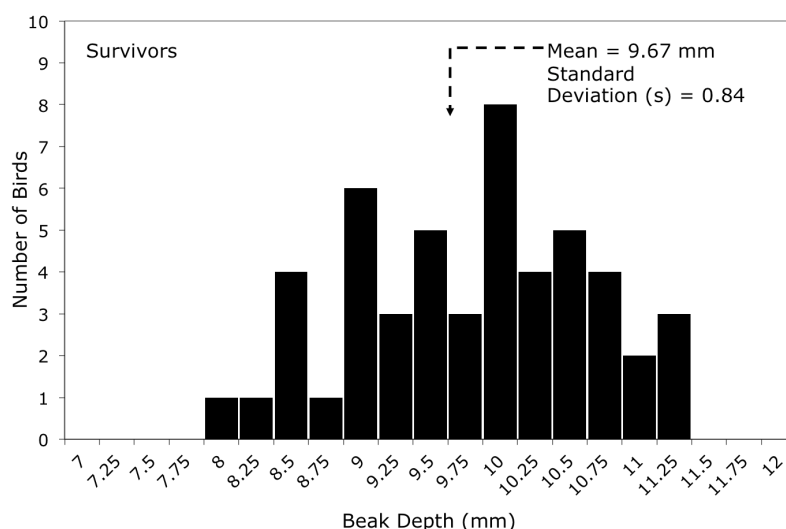


Figure 3. Histograms showing the beak depths, measured in millimeters (mm), of 100 medium ground finches from Daphne Major.



The top graph shows the beak depths of the nonsurvivors (50 birds that did not survive the drought of 1977).

The bottom graph shows the beak depths of the survivors (50 birds that survived the drought and were still alive in 1978).

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Use Figure 3 to answer the following questions.

3. Observe the shapes of the graphs. It may help to draw a line connecting the tops of the black bars.
 - a. Describe the overall shape of each graph.
 - b. What do the shapes of the graphs indicate about the distribution of beak depths in these two groups of birds?
4. Compare and contrast the distributions of beak depths for the survivors and nonsurvivors. For each distribution, include the range of the data and the most common measurements.
5. Propose a biological hypothesis to explain the differences in the distribution of beak depths for the survivors and nonsurvivors. (*Hint*: It may help to review your answers for Part 1.)

Each graph also lists the **mean** (average) beak depth for that group of birds, as well as the **standard deviation** (*s*) for beak depth in that group. Standard deviation indicates the amount of variation in a set of measurements — in other words, how spread out the measurements are. A *larger* standard deviation means that the measurements are *more* spread out.

In each of these groups, most of the measurements fall within one standard deviation from the mean. The beak depths of the nonsurvivors, for example, have a mean of 9.11 mm and a standard deviation of 0.88 mm. Most of the birds in this group have beak depths that are between 8.23 mm (one standard deviation below the mean) and 9.99 mm (one standard deviation above the mean).

6. Take a look at the means and standard deviations of beak depth in each group.
 - a. How do these means and standard deviations compare between the groups?
 - b. If the standard deviations of the two groups were very different, what would you conclude about the groups?

PART 3: Examining the Importance of Sample Size

The Grants measured beak depths of hundreds of birds every year, and this extraordinary effort was critical to their discoveries. But why was it important to collect data on so many birds?

Let's see what could have happened if they'd had data from far *fewer* birds. Table 1 below shows data from much smaller samples (5 or 15 birds), which were randomly selected from the larger data set you saw earlier (which had 50 nonsurvivors and 50 survivors).

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Table 1. Beak depths (mm) in random samples of nonsurvivors and survivors.

Nonsurvivors				Survivors			
5-bird sample		15-bird sample		5-bird sample		15-bird sample	
Bird ID #	Beak Depth (mm)	Bird ID #	Beak Depth (mm)	Bird ID #	Beak Depth (mm)	Bird ID #	Beak Depth (mm)
12	7.52	283	11.20	943	9.10	316	9.85
347	9.31	288	9.10	1643	8.80	623	8.80
413	8.20	294	10.50	1884	9.15	673	10.10
522	8.39	315	8.80	2244	11.01	678	9.70
609	10.50	321	8.48	8191	10.86	891	8.00
		352	7.70			1019	11.21
		413	8.20			1477	10.10
		468	9.02			1528	8.55
		503	9.10			1797	9.31
		507	8.85			1850	10.40
		561	10.20			1884	9.15
		610	9.00			2242	9.45
		619	9.25			2378	9.86
		621	7.60			2249	10.68
		676	9.70			2939	8.31
Mean		Mean		Mean		Mean	
s		s		s		s	

The mean and standard deviation of each sample have been left blank for you to calculate in the questions below. You can calculate them using a calculator or spreadsheet program. To calculate the standard deviation of the sample (s), you can use the equation and steps below:

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{(n - 1)}}$$

- Calculate the mean (\bar{x}) of the sample.
- For each measurement (x_i) in the sample, determine the difference between that measurement and the mean. This will be $(x_i - \bar{x})$.
- Square the difference you got in the previous step. This will be $(x_i - \bar{x})^2$.
- Add up all of the squared differences to get $\sum(x_i - \bar{x})^2$. The symbol Σ represents summation, or adding together.
- Divide your result by the number of birds in the sample (n) minus 1.
- Take the square root of your result.

7. For each sample, calculate the mean beak depth and standard deviation (s). Record your answers in Table 1.

8. Record the means and standard deviations for each sample of survivors and nonsurvivors (the 50-bird samples in Figure 3, then the 15-bird and 5-bird samples in Table 1) in Table 2.

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Table 2. Means and standard deviations of beak depths (mm) in different samples of nonsurvivors and survivors.

	Mean			Standard deviation		
	50-bird sample	15-bird sample	5-bird sample	50-bird sample	15-bird sample	5-bird sample
Nonsurvivors						
Survivors						

9. Compare the means and standard deviations for the samples in Table 2.
 - a. Are the means in smaller samples different from the means in larger samples? Explain why you think that is.
 - b. Are the standard deviations in smaller samples different from the standard deviations in larger samples? Explain why you think that is.
10. Which results (from 5, 15, or 50 birds) do you think are *closest* to the means and standard deviations of the entire population of medium ground finches on the island? Explain your answer.
11. What is one advantage and one disadvantage of calculating the mean from a *sample* of a population rather than the *entire* population?

PART 4: Adaptive Traits and Constructing Bar Graphs

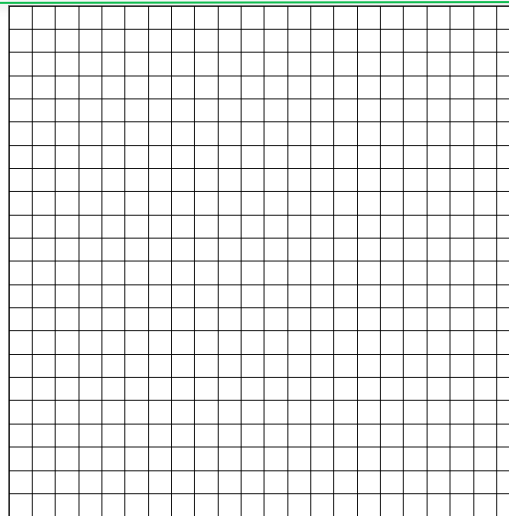
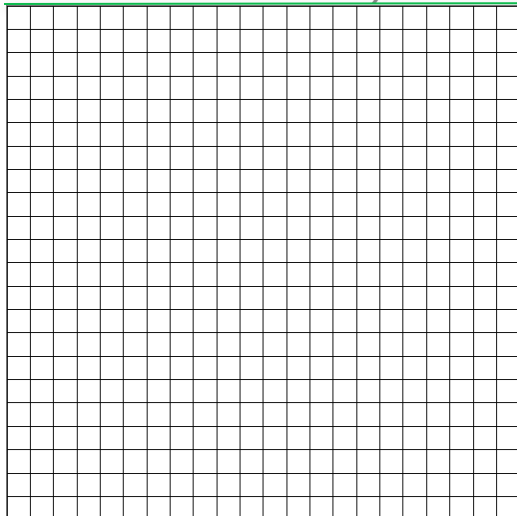
In addition to beak depth, Peter and Rosemary Grant collected measurements for dozens of other finch traits, such as wing length and body mass. Table 3 summarizes the means of body mass and wing length for samples of nonsurvivors and survivors.

Table 3. Means of body mass and wing length for 50 nonsurvivors and 50 survivors.

	Body mass		Wing length	
	Nonsurvivors	Survivors	Nonsurvivors	Survivors
Mean	15.70 g	17.00 g	67.8 mm	69.3 mm

Let's compare the means of these traits in the two groups using graphs. A **bar graph** is often a good choice for comparing a single numerical value among different groups.

12. Construct two bar graphs, one comparing the means of *wing length* for the two groups and another comparing the means of *body mass*.
 - You can draw the graphs by hand below, or you can make them on a computer using [Data Explorer](#) (under the “Visualize” tab at the top) or another program. Make sure to include all your graphs when submitting this handout.
 - For each graph, make sure to include a title and labels for the axes (including units).



13. Based on your graphs, how does the mean wing length compare between survivors and nonsurvivors? What about the mean body mass?

14. What do your graphs suggest about the effects of the drought on birds with particular wing lengths and body masses?

15. The film in Part 1 claimed that beak depth is the trait that made the greatest difference in survival for the birds during the drought. Do the data you examined support this claim? Explain your answer.

16. Based on what you learned from the film, why might beak depth play a more important role in survival during the drought than either wing length or body mass? (*Hint*: According to the film, what was the main impact of the drought on the finches?)

17. How might variation in key traits within a population, such as beak depth in medium ground finches, make that population more likely to survive environmental changes?