EVOLUTION IN ACTION: GRAPHING AND STATISTICS

Adapted from HHMI – Biointeractive.org

Introduction:

Relatively few researchers have been able to witness evolutionary change in their lifetimes; among them are Peter and Rosemary Grant. The short film *The Beak of the Finch* focuses on the Grants' 40-year study of the finches of the Galápagos Islands. In 1973, the Grants began observing and studying finches on several islands in the Galápagos archipelago. They wanted to understand how species change over time and, in particular, how changes in the environment can influence a species' physical characteristics.

As part of their work, the Grants intensively studied the population of medium ground finches (*Geospiza fortis*) on the island of Daphne Major. Every year, the Grants measured the wing length, body mass, and beak size of hundreds of individual medium ground finches. They focused on these characteristics because they vary widely among individual birds within the same species –for example, some birds in a population will be larger than other birds or have bigger beaks, even though they all belong to the same species. It is normal for heritable traits to vary among individuals in a population because no two individuals, except for twins, are genetically identical. In some cases, individuals with one form of a trait, such as a larger beak, will have a survival advantage over individuals with a different form of the trait, such as a smaller beak. Those advantageous traits may make it more likely for some individuals to survive and produce more offspring, and therefore are more likely to be passed on to the next generation. This process is what Charles Darwin called natural selection.

The medium ground finch (*Geospiza fortis*). The medium ground finch is one

In the film The Beak of the Finch the Grants described the findings from their research: When the weather changed drastically on the island of Daphne Major, individuals with a particular beak size were more likely to survive. In this activity, you will analyze some of the actual measurements that Peter and Rosemary Grant collected. You will interpret their data and suggest hypotheses to explain their observations. In addition, you will use their data to construct graphs and learn why it was important for the Grants to collect data on so many birds. Finally, you will propose how and why some characteristics are more likely than others to change from one generation to the next under specific environmental conditions.

PROCEDURE

Part A: Introducing the Data Set

Every year for 40 years, Peter and Rosemary Grant carefully measured the physical characteristics of hundreds of individual medium ground finches living on the island of Daphne Major. In an accompanying Excel spreadsheet, the Grants have provided the measurements they took in a sample of 100 birds born between 1973 and 1976.

For this part of the activity, you should familiarize yourself with the dataset, as instructed by your teacher.

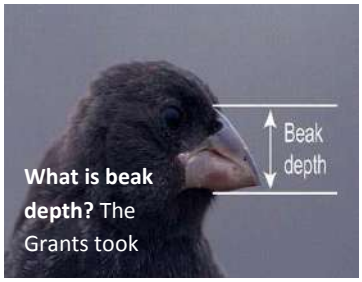
Note that the sample provided by the Grants includes 50 ground finches that lived until 1977. That year, an 18-month-long drought began that resulted in the death of more than 80% of the medium ground finches on the island. The other 50 finches in the dataset survived the drought and lived to 1978 and beyond.

Part B: Analyzing Graphical Data

Although you may have been able to see some differences between the two groups of birds by looking at the data in the spreadsheet, one way to more clearly visualize such differences is to graph the data. Figure 1 shows two graphs of beak depth measurement for the 50 medium ground finches that died in 1977 and did not survive the drought (nonsurvivors) and the 50 medium ground finches that lived beyond 1977 and survived the drought (survivors).

Each graph includes average (mean) beak depth and standard deviation (s) for that group of birds.

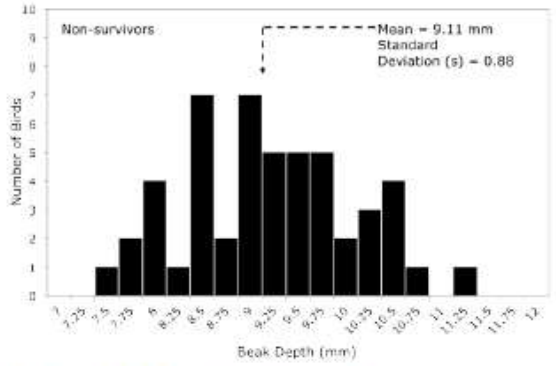
Standard deviation quantifies the amount of variation in a set of measurements. Simply put, it is a measure of how spread out the numbers are. The larger the standard deviation, the more the data points are spread out for a measured characteristic, such as beak depth, in a population. In the two graphs in Figure 1, the standard deviations are 0.88 and 0.84, meaning that most birds in the first sample have beak depths that are plus or minus 0.88 mm of the mean of 9.11 mm and most birds in the second sample have beak depths that are plus or minus 0.84 mm of the mean of 9.67 mm.



What is beak depth? The Grants took

Study the information provided in the graphs and then answer questions 1–4. To answer some of the questions, you will need to recall from the film what major change occurred on the island as the drought progressed.

Beak Depths of 50 Medium Ground Finches That Did Not Survive the Drought



Beak Depths of 50 Medium Ground Finches That Survived the Drought

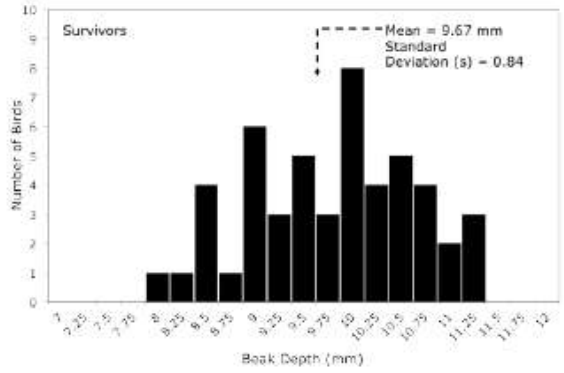


Figure 1. The two graphs above show the beak depths, measured in mm, of 100 medium ground finches from Daphne Major. Fifty birds did not survive the drought of 1977 (top graph). The other 50 birds survived the drought and were still alive in 1978 (bottom graph).

1. What observations can you make about the overall shape of each graph? (Imagine that you are drawing a line that connects the tops of the horizontal bars.)
2. What do the shapes of the two graphs indicate about the distribution of beak depth measurements in these two groups of medium ground finches?
3. Compare the distribution of beak depths between survivors and nonsurvivors. In your answer, include the shape of the distributions, the range of the data, and the most common measurements.
4. Based on what you saw in the film, think about how changes in the environment may have affected which birds survived the drought. Propose a hypothesis to explain differences in the distribution of beak depths between survivors and nonsurvivors.
5. Let's look in more detail at the mean beak depths in the two groups of birds to understand the meaning of standard deviation.
6. How do the mean beak depths and standard deviations of the mean beak depths compare?
7. If the standard deviation of the two samples were to be vastly different, what would you conclude about the two groups?

Band refers to an individual's identity; more specifically, the number on a metal leg band it was given. **Species** name is *Geospiza fortis* , which is the medium ground finch. **Sex** is indicated as male, female, or unknown. The reason for the "unknown" category is that males start their lives looking like females; after one or more years they molt into a plumage with some black feathering that indicates they are males. The heading "**first adult year**" refers to the year after the individual hatched from an egg. The heading "**last year**" refers to the last year of that individual's life. Fifty individuals did not survive beyond 1977, the year of the drought, whereas 50 survived to 1978 and later years. The next six columns provide the morphological measurements of individuals in the group that died in 1977 and in the group that survived. **Weight** is in grams; the other measurements are in millimeters. **Tarsus** is part of the leg.

Band	Species	Sex	First adult year	Last Year	Weight (g)	Wing (mm)	Tarsus (mm)	Beak Length (mm)	Beak Depth (mm)	Beak Width (mm)
9	Geospiza fortis	unknown	1975	1977	14.50	67.00	18.00	9.20	8.30	8.10
12	Geospiza fortis	female	1975	1977	13.50	66.00	18.30	9.50	7.50	7.50
506	Geospiza fortis	female	1975	1977	17.00	69.00	18.60	11.10	9.20	8.90
507	Geospiza fortis	male	1973	1977	16.00	70.00	19.00	10.30	8.80	8.10
509	Geospiza fortis	male	1973	1977	17.00	70.00	20.00	11.10	9.20	9.00
511	Geospiza fortis	male	1975	1977	14.50	66.00	19.10	10.50	8.80	8.50
512	Geospiza fortis	unknown	1975	1977	15.50	67.00	20.30	11.00	9.40	8.70
519	Geospiza fortis	male	1973	1977	14.50	67.00	19.10	10.00	8.30	7.90
522	Geospiza fortis	female	1975	1977	15.50	66.00	18.20	10.30	8.40	8.00
561	Geospiza fortis	unknown	1975	1977	16.50	70.00	20.00	11.70	10.20	8.90
564	Geospiza fortis	unknown	1975	1977	14.00	66.00	18.80	10.20	9.30	8.20
605	Geospiza fortis	unknown	1975	1977	15.50	71.00	19.90	10.90	10.20	8.90
609	Geospiza fortis	male	1975	1977	16.50	69.00	19.60	11.90	10.50	9.00
610	Geospiza fortis	male	1975	1977	14.00	66.00	18.80	10.20	9.00	8.30
611	Geospiza fortis	female	1975	1977	16.00	66.00	18.90	10.50	9.80	9.10
619	Geospiza fortis	unknown	1975	1977	14.00	65.00	18.00	10.50	9.30	8.50
621	Geospiza fortis	male	1973	1977	15.50	67.00	18.50	9.80	7.60	7.80
674	Geospiza fortis	male	1973	1977	18.50	70.00	20.50	11.80	10.50	9.30
676	Geospiza fortis	male	1975	1977	17.00	72.00	20.00	11.00	9.70	8.90
687	Geospiza fortis	unknown	1975	1977	14.00	66.00	18.30	10.30	8.60	7.80
303	Geospiza fortis	male	1973	1978	18.00	71.00	20.20	11.50	9.80	9.20
560	Geospiza fortis	unknown	1975	1978	14.00	67.00	19.10	10.20	8.50	8.20
1452	Geospiza fortis	unknown	1976	1978	16.24	68.19	18.47	11.43	9.80	8.50
1477	Geospiza fortis	unknown	1976	1978	17.34	70.19	20.57	11.93	10.10	9.50
1528	Geospiza fortis	male	1976	1978	17.09	68.19	19.32	11.03	8.55	8.10
2211	Geospiza fortis	unknown	1976	1978	16.94	70.19	19.27	11.03	9.70	8.90
2226	Geospiza fortis	unknown	1976	1978	14.74	65.19	18.27	10.23	8.90	8.30
2697	Geospiza fortis	female	1976	1978	17.34	69.19	19.07	11.33	10.10	9.40
8138	Geospiza fortis	unknown	1976	1978	15.54	68.19	18.07	10.03	8.90	8.00
616	Geospiza fortis	male	1975	1979	19.00	70.00	20.00	10.70	9.60	8.90
1249	Geospiza fortis	male	1976	1979	15.40	66.00	19.50	10.00	8.50	8.30
2219	Geospiza fortis	male	1976	1979	16.24	68.01	18.96	12.43	10.09	8.54
2242	Geospiza fortis	male	1976	1979	15.41	72.94	18.26	11.09	9.45	8.03
2939	Geospiza fortis	unknown	1973	1979	15.37	67.95	19.41	9.63	8.31	7.72
354	Geospiza fortis	female	1975	1980	17.50	67.00	20.30	11.60	9.80	9.10
678	Geospiza fortis	male	1973	1980	16.50	71.00	18.20	11.30	9.70	8.30
1418	Geospiza fortis	male	1976	1980	17.94	71.01	18.78	12.13	10.38	9.24
1426	Geospiza fortis	female	1976	1980	21.22	71.45	21.01	12.03	10.61	10.07
2249	Geospiza fortis	male	1976	1980	18.44	74.01	20.06	12.73	10.68	9.74
2940	Geospiza fortis	female	1976	1980	15.14	70.01	17.86	10.33	8.78	8.14
3642	Geospiza fortis	male	1973	1980	17.84	71.01	19.16	11.03	10.28	9.04
8191	Geospiza fortis	male	1976	1980	19.63	70.41	20.81	12.53	10.86	9.62
1019	Geospiza fortis	male	1976	1981	20.82	70.45	19.86	12.13	11.21	9.87
1372	Geospiza fortis	female	1976	1981	16.64	69.01	18.16	10.43	9.48	8.54
1797	Geospiza fortis	male	1976	1982	16.67	69.45	19.21	10.53	9.31	8.37
2378	Geospiza fortis	male	1976	1981	18.07	70.95	21.06	11.23	9.86	8.67
8190	Geospiza fortis	unknown	1976	1981	15.60	69.47	18.36	11.23	9.28	8.24
316	Geospiza fortis	male	1973	1982	17.55	67.50	19.55	10.90	9.85	9.20
710	Geospiza fortis	male	1975	1982	15.00	69.00	19.00	10.50	10.00	8.70