Using Data to Investigate Elephant Evolution

hhmi | BioInteractive

Activity

Student Handout (Version 2)

INTRODUCTION

In this activity, you'll investigate real data from elephants to learn how and why populations may change over time. First, you'll explore the data set and come up with a question that interests you. Then, you'll try to answer your question by creating a plot (graph) and doing a statistical analysis with the data. Finally, you'll use the data to investigate specific changes in the elephant populations that could be caused by humans. By doing this activity, you'll learn about forces that can drive changes in all populations. And you'll also practice data exploration and analysis skills that can help you understand all kinds of data.

MATERIALS

- the elephant data set (in *Data Explorer* or as a spreadsheet)
- access to *Data Explorer* or a spreadsheet program

PART 1: Exploring the Data Set

The data you're exploring come from African elephants. Many African elephant populations are shrinking due to hunting, habitat loss, and other threats. These populations are also changing in terms of the **traits**, or characteristics, of their individuals. For example, certain traits have become more common in some populations over time.

These data were collected to investigate possible changes in elephant populations along the Kenya-Tanzania border. The locations of the populations are shown in Figure 1. The data set includes elephants from two different time periods: an older period (1966–1968) and a more recent one (2005–2013).

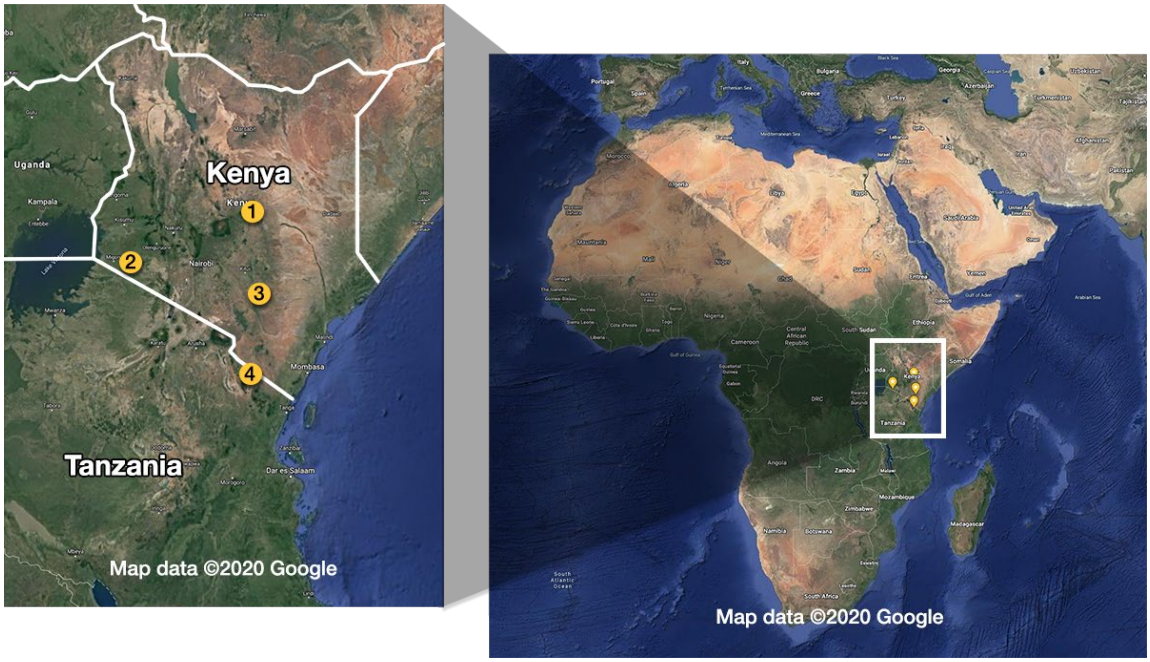

Figure 1. Locations of the elephant populations included in the study (1: Meru National Park, Kenya; 2: Masai Mara National Reserve, Kenya; 3: Tsavo East National Park, Kenya; 4: Mkomazi National Park, Tanzania). Data from the 1966–1968 time period came from locations 3 and 4. Data from the 2005–2013 time period came from locations 1, 2, and 3.

For elephants in both time periods, scientists recorded traits such as sex, estimated age, shoulder height, tusk length, and tusk circumference. Figure 2 shows how some of the measurements were taken.

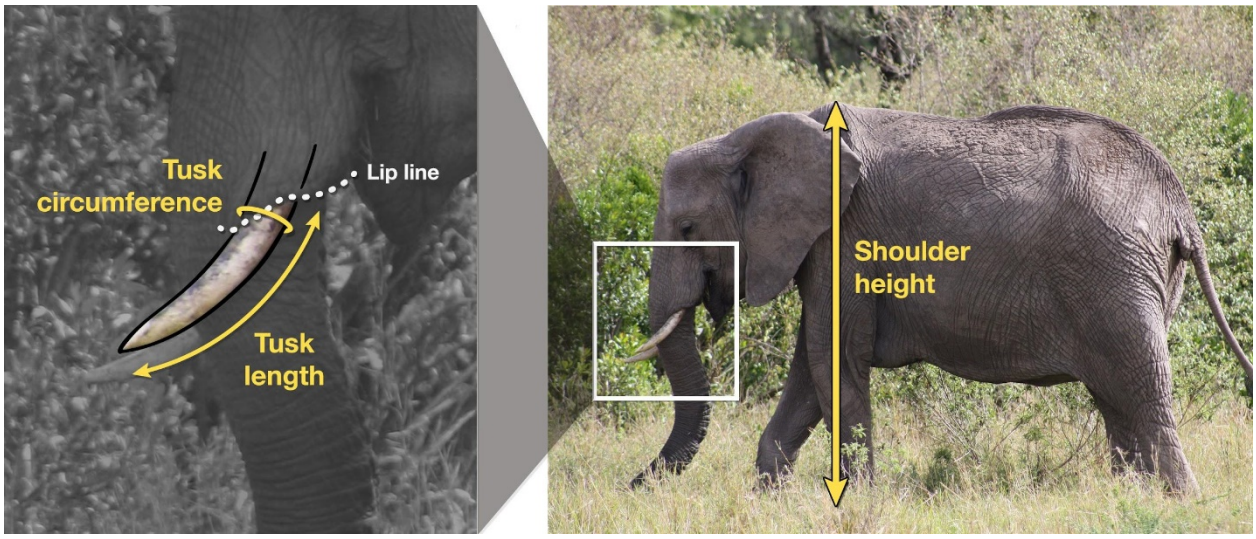

Figure 2. Diagrams showing how an elephant's body and tusk measurements were taken.

Open the elephant data set. In *Data Explorer*, you can do this by clicking "Choose data to explore" on the landing page, selecting the "Elephant populations under poaching" data set, and then clicking the **"Data"** tab at the top. Spend some time familiarizing yourself with the data.

1. Give a reason why collecting these types of data on elephants could be useful. For example, what do you think these data could help us learn or do? If you want, you can pick a specific part of the data to focus on.

2. The data set shows different variables in different columns. There are two types of variables: numerical and categorical. In general, what is the difference between numerical and categorical variables?

3. Find one elephant that is missing data for one or more variables. What data is missing, and why might it be missing?

PART 2: Investigating a Research Question

In Part 1, you explored the entries of the data set. Other ways to explore data include visualizing it with a plot (graph) or performing a statistical analysis.

4. Come up with a research question that is interesting to you *and* that you think you could answer with a plot or statistical analysis.

5. Write a hypothesis for your research question.

6. Plan a plot (graph) that could help you test your hypothesis. Feel free to explore several types of plots before choosing the one best suited to your purpose.
   a. What type of plot are you going to make? Why did you choose that plot type?

   b. Create your plot in *Data Explorer* (under the **"Visualize"** tab at the top) or another program, as directed by your instructor. Make sure to include the plot when submitting this handout.
   c. Summarize what you observe from your plot, including any patterns or relationships. Does the plot support the hypothesis you made earlier? Why or why not?

7. Plan a statistical analysis that could help you test your hypothesis or learn more about the patterns or relationships you observed from your plot.
   a. What type of analysis are you going to do? Why did you choose that analysis?

   b. Do your analysis in *Data Explorer* (under the "**Analyze"** tab at the top) or another program, as directed by your instructor, then summarize your results. Does the analysis support the hypothesis you made earlier? Why or why not?

PART 3: Investigating the Impacts of Poaching

Many interesting research questions can be investigated with this data set. One question explored by the scientists who collected the data involves the impacts of **poaching**: the illegal hunting of wild animals by humans.

In the late 1970s and early 1980s, these elephant populations experienced heavy poaching. Poachers (humans who poach) killed many elephants in order to take their tusks for **ivory**: a hard, valuable material used in jewelry, ornaments, and more. Larger tusks have more ivory, so poachers targeted elephants with larger tusks more often.

The poaching of elephants and other animals has reduced many wild populations. Poaching can also cause other long-lasting changes that affect the types of traits in a population. In the late 1800s and early 1900s, for example, foxes in Canada were heavily hunted for their fur. The hunters considered silver fur more valuable than red fur. So, silver foxes were more likely to be killed than red foxes were (Figure 3). Over time, the red fur trait became much more common. Even decades later, foxes with silver fur are still rare in this population.

Figure 3. Examples of foxes with red fur (left) and silver fur (right).

8. Based on what you learned about the fox population, which traits do you think were affected by poaching in the elephant populations? How might the elephant populations have changed over time as a result?

To investigate the impacts of poaching, scientists compared the traits of elephants from 1966–1968 (*before* heavy poaching) to those of elephants from 2005–2013 (*after* heavy poaching). Two traits they looked at were tusk length and tusk circumference, which are measures of tusk size.

9. Would you expect the elephants from the two different time periods to have different tusk lengths or circumferences? Why or why not?

10. To see if the data support your expectations, you'll now create plots to compare mean tusk lengths and circumferences for the elephants from the two different time periods. You can make the plots in *Data Explorer* or another program, as directed by your instructor. Make sure to include the plots when submitting this handout.
    a. Which type of plot would you use to compare the means of two groups?

    b. Create a plot to compare the **mean tusk lengths** of the elephants from the two periods: **1966–1968** (before poaching) and **2005–2013** (after poaching).
    c. Create a plot to compare the **mean tusk circumferences** of the elephants from the two periods: **1966–1968** (before poaching) and **2005–2013** (after poaching).
    d. Summarize what you observed from these two plots, including any patterns or trends.

11. You may have observed some differences in the mean tusk lengths and circumferences of the elephants before and after poaching. But even if the mean values differ, these differences may or may not be **statistically significant**.
    a. What does it mean for a difference to be "statistically significant"?

    b. Why would it be useful to know whether differences between the elephants before and after poaching are statistically significant?

12. One way to determine whether a difference in means is statistically significant is by using **95% confidence intervals**, which can be shown on a graph as error bars.
    a. What is a 95% confidence interval (also written as 95% CI)?

    b. When do error bars for 95% CIs suggest that a difference in means is statistically significant?

    c. Add error bars for 95% CIs to your plots of mean tusk length and mean circumference. Make sure to include the plots with error bars when submitting this handout.
    d. Based on these error bars, is there a statistically significant difference in the *mean tusk length* for the elephants before and after poaching? Or can you not tell?

e. Based on these error bars, is there a statistically significant difference in the *mean tusk circumference* for the elephants before and after poaching? Or can you not tell?

13. Another way to determine whether a difference in means is statistically significant is by doing a statistical analysis.
    a. Which statistical analysis would you use to compare the means of two groups?

    b. Use the analysis to compare the *mean tusk length* for elephants before and after poaching. Summarize your results and whether they indicate that the difference in means is statistically significant.

    c. Use the analysis to compare the *mean tusk circumference* for elephants before and after poaching. Summarize your results and whether they indicate that the difference in means is statistically significant.

    d. Did you discover anything new from your statistical analysis that you didn't already learn from the error bars? If so, what?

14. Summarize what you learned from your plots and analyses. How do the results compare to what you expected in Question 9? Why do you think the results are the way they are?

PART 4: Elephant Evolution

Many elephant traits, including tusk length and tusk circumference, are likely to be at least partially **inherited** (passed from parents to offspring). Changes in these traits within the elephant populations may indicate changes in the frequency of related genes, which is known as **evolution**. Evolution can be driven by many forces in the environment, including human activities such as poaching.

15. Consider the following conditions required for evolution. Describe how you think each condition applies to the elephant populations under poaching. Provide evidence based on the data set, your plots and statistical analyses, and/or information you learned in this activity.

Condition	Description	Evidence in the elephant population
Variation	There is variation in the trait of interest (e.g., tusk size) in the population.	
Inheritance	The trait of interest is at least partially inherited.	
Differential survival and reproduction	Individuals with a certain version of the trait are more likely to survive and reproduce than individuals with a different version of the trait.	
Adaptation	The version of the trait that helps individuals survive and reproduce becomes more common in the population over generations. (The average generation time for African elephants is 25 years.)	

16. Poaching has decreased a lot since the 1980s. Why might poaching still affect mean tusk size in 2005–2013? (*Hint*: The average generation time for African elephants is 25 years.)

17. If there is no more poaching in the future, how might the mean tusk size in 100 years differ from the mean tusk size in 2005–2013? (*Hint: African* elephants use their tusks to strip bark off trees for food and to dig up water from the ground. Larger tusks are useful for these tasks.)

18. In addition to changes in tusk size, how else might elephant populations change due to poaching?