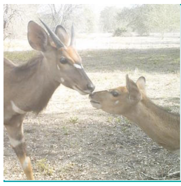


GORONGOSA: SCIENTIFIC INQUIRY & DATA ANALYSIS

OVERVIEW

This activity complements WildCam Gorongosa (http://www.wildcamgorongosa.org), an online citizen science platform for identifying animals photographed by motion-detecting trail cameras located throughout Gorongosa National Park. This activity builds on the "Making Observations" activity (http://www.hhmi.org/biointeractive/gorongosa-making-observations-activity), in which students use trail camera photos to make observations and ask scientific questions. This activity can be completed following the "Making Observations" activity or as a standalone.

The scientific process is flexible and iterative. In this activity, students will be guided through the investigation of a scientific question, using data from ongoing research in Gorongosa National Park. Students will begin by reading about the ecology of Gorongosa and use this knowledge to inform their investigation. They will then explore a spreadsheet of trail camera data and identify a testable question that could be investigated using this data set. If they performed the "Making Observations" activity, they can select a testable question that they previously generated. Based on their question, students will formulate a hypothesis and prediction, which they will test using the available data. The process will require students to select variables to include in their analysis and the graphing of data using a spreadsheet program.

This activity is highly differentiated and can be adapted for various levels. Parts 1 and 2 offer teachers a chance to model the process for students using already-defined questions. Parts 1 through 3 allow students to develop their own inquiry and analysis in a scaffolded way. Part 4 encourages students to think critically about the research and inquiry process. A spreadsheet tutorial, example questions, and background reading on the ecology of Gorongosa are included to support teachers and students with this activity.

KEY CONCEPTS

- The process of scientific inquiry begins by making detailed observations of the natural world and formulating questions.
- The process of scientific inquiry is typically iterative and nonlinear.
- Testable scientific questions are questions that can be answered by experimentation or collecting data through observations.
- Questions lead to hypotheses and/or predictions that can be tested with further observations or carefully designed experiments.
- The location and abundance of animals are determined by the availability of resources and community interactions, such as competition, predation, and human influences.

LEARNING OBJECTIVES

Students will be able to:

- Develop testable ecological questions based on an available data set.

- Formulate hypotheses and predictions about the questions that they posed.
- Analyze data and describe trends to investigate their questions.

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	HS-LS2-1, HS-LS2-2, HS-LS2-8 Practice 1.
Common Core (2010)	RST.9-12.7, WHST.9-12.7, HSS.IC.B.5, HSS.ID.B.5
AP Biology (2012–13)	2.C.2, 2.D.1, 2.E.3
IB Biology (2016)	
AP Environmental Science (April 2013)	II.A, II.D

KEY TERMS

Scientific inquiry, observation, testable question, hypothesis, prediction, Gorongosa, ecosystem, habitat, vegetation type, savanna, grassland, woodland, limestone gorge, biodiversity, abundance

TIME REQUIREMENTS

Parts 1 and 2 can be completed in one 50-minute class period. Parts 3 and 4 can be completed in a second 50-minute session depending on student abilities with data analysis. Alternatively, Part 4 could be assigned as homework if class time is limited.

SUGGESTED AUDIENCE

This activity is appropriate for high school biology (all levels including AP and IB), high school environmental science (all levels including AP and IB), and introductory college biology or ecology.

PRIOR KNOWLEDGE

- It is recommended that students be introduced to the WildCam Gorongosa website and perform some animal identifications prior to conducting this activity, as a way to engage and provide context.
- Students can also watch the Scientist at Work film "Tracking Lion Recovery in Gorongosa National Park" (http://www.hhmi.org/biointeractive/tracking-lion-recovery-gorongosa-national-park) to gain an appreciation of how the trail camera data are collected and the kinds of studies being conducted using these data.
- If time permits, completing the "Creating Chains and Webs to Model Ecological Relationships" activity (http://www.hhmi.org/biointeractive/creating-chains-and-webs-model-ecological-relationships) and the "Making Observations" activity prior to this activity would be beneficial but is not necessary.

- A spreadsheet tutorial and background reading on Gorongosa ecology are provided as part of this activity for support and background information.

MATERIALS

- Printed copies of the student worksheet
- Computers for each student or group with a spreadsheet program. Microsoft Excel is recommended, but the files can be used with Google Sheets and Numbers as well.
- (Optional) Computer with projector to demonstrate spreadsheet tutorial and graph creation.

PROCEDURES

Prior to Class

- Depending on how you decide to work through the activity, you may want to have a projector connected to a computer to display the spreadsheet and demonstrate the spreadsheet tutorial.
- Each student or group of students must have a computer with spreadsheet software and have downloaded the spreadsheet file and tutorial to the computer.
- Print one student handout for each student or group.

Part 1: Testable Questions

1. Distribute the student handout and instruct students to read the introduction, the first paragraph of the procedures section, and Appendix 1 ("Gorongosa Ecology").
2. Instruct students to open the data spreadsheet and read the first paragraph in "Part 1: Testable Questions." The second tab of the spreadsheet explains each of the data columns.
3. Instruct students to complete questions 1 through 3 in their handouts.
4. Before students complete question 4, you may decide to engage in a class discussion on what makes a testable question or have students discuss their answers to questions 1 through 3 in their groups.
5. Instruct students to complete question 4. They can refer to the Appendix for basic ecology information. If they need inspiration, they may identify animals on WildCam Gorongosa and make some observations about the animals that they see in photos and the questions that they have. If your students have already completed the "Making Observations" activity, they can simply choose from the questions that they generated.

Part 2: Making Hypotheses and Predictions

1. Instruct your students to read Part 2 of the handout.
2. This may be a good time to lead the class in a discussion about the iterative process of scientific investigations. In addition to hypotheses and predictions, you can describe other approaches to inquiry (such as claim, evidence, and reasoning), and describe that scientific inquiry is often iterative and not always a linear step-by-step process.
3. Instruct your students to complete question 5.

Part 3: Data Analysis

1. Instruct your students to go through the spreadsheet tutorial that will guide them through the process of analyzing data to investigate the question: *Which vegetation type in Gorongosa has the highest abundance of animals?*
2. When they have produced the appropriate graph, they may print the graph and attach it to their handout or take a screenshot and send it to you digitally.
3. Instruct your students to work through questions 7 through 13.

Part 4: Analyzing Data Discussion

1. Instruct your students to answer questions 14 through 17. This section can be completed as homework if class time is limited.

TEACHING TIPS

- While this activity is aimed at giving students experience with analyzing data using a spreadsheet on a computer, it can be adapted to be a whole-group activity using a projector if computers are not available for the entire class.
- Prior to implementing this activity, it would be helpful for the teacher to complete the spreadsheet tutorial and to review the spreadsheet and read the descriptions of the variables. This review will be helpful for anticipating student questions during the actual lesson.
- The Gorongosa Interactive map is an excellent resource to get more ecological information about Gorongosa. If a student has a question about the general ecology of Gorongosa, have them research it using the interactive map or the Gorongosa National Park website (www.gorongosa.org).
- The process of scientific inquiry is not always linear and can be approached in many ways. This activity presents one approach. It's important to emphasize to students that scientists typically repeat or revise certain steps in the process as new information is gathered. There are also other ways to frame questions and design investigations beyond the hypothesis-prediction model. You may want to leave time to discuss other approaches with your class.
- The spreadsheet tutorial is currently available in Excel format; however, it can also be used with Google Sheets and Numbers. Google Sheets and Numbers versions of the spreadsheet and tutorial will be produced in a subsequent release of this activity.

RELATED RESOURCES

WildCam Gorongosa
(http://www.hhmi.org/biointeractive/wildcam-gorongosa)
Researchers in Gorongosa National Park use remote trail cameras to study the park's wildlife. This online citizen science platform allows participants to help scientists identify animals in these photos.

Creating Chains and Webs to Model Ecological Relationships
(http://www.hhmi.org/biointeractive/creating-chains-and-webs-model-ecological-relationships)
In this activity, students use cards to build model food webs and evaluate how ecological disturbances affect each trophic level.

Gorongosa: Making Observations
(http://www.hhmi.org/biointeractive/gorongosa-making-observations-activity)
In this activity, students will use trail camera photos from WildCam Gorongosa to make observations and ask scientific questions as part of the scientific process.

Tracking Lion Recovery in Gorongosa National Park
(http://www.hhmi.org/biointeractive/tracking-lion-recovery-gorongosa-national-park)
This Scientist at Work film explores how scientists in Gorongosa National Park are using GPS satellite collars and motion-sensitive cameras to gather information about the park's lion population.

Gorongosa National Park Interactive Map
(http://www.hhmi.org/biointeractive/gorongosa-national-park-interactive-map)
This interactive map of Gorongosa National Park allows users to explore different features of the park, including key components of the conservation strategy.

The Guide: A Biologist in Gorongosa
(http://www.hhmi.org/biointeractive/the-guide-a-biologist-in-gorongosa)
This is a short film about a young man from Gorongosa who discovers a passion for science after meeting world-renowned biologist E.O. Wilson.

ANSWER KEY

1. *Which lions in Gorongosa are genetically related to one another?*

   Is this question testable using the data in the spreadsheet? If so, which variables would you include in your analysis? If not, what additional data would you need to test this question?
   This question is not testable using the data in the spreadsheet. In order to answer this question, I would need genetic information about each lion in Gorongosa National Park.

2. *Which vegetation type in Gorongosa supports the highest abundance of animals?*

   Is this question testable using the data in the spreadsheet? If so, which variables would you include in your analysis? If not, what additional data would you need to test this question?
   This question is testable using the data in the spreadsheet. In order to test this question, I would use the "number of individuals" and the "vegetation type" variables.

3. *Why are baboons often found in groups?*

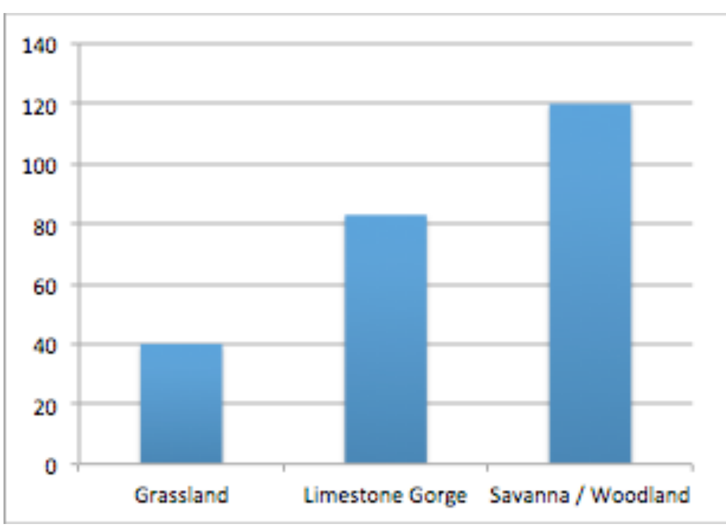
   Is this question testable using the data in the spreadsheet? If so, which variables would you include in your analysis? If not, what additional data would you need to test this question?
   This question is not testable using the data in the spreadsheet. In order to test this question, I would need to design an experiment or make observations about the competitive advantages and fitness of solitary baboons and social baboons.

4. *What is your question and what variables from the spreadsheet would you use to test this question?*
   Answers will vary.

5. *Now it's your turn to try. Using your testable question from #4 above, formulate a hypothesis and a prediction.*
   Answers will vary.

7. *Which two variables did you compare?*
   The two variables being compared in this graph are number of animals and vegetation type.

8. *Describe the trends that you see in your graph.*
   This graph shows three bars that represent the number of animals seen in trail cameras in the following vegetation types: grassland, limestone gorge, and savanna/woodland. The vegetation type with the highest number of animals is the savanna/woodland with 120 animals, followed by limestone gorge with approximately 80 animals. Grassland has the lowest number of animals with approximately 40 animals.



9. *Based on this graph, are the hypothesis and prediction from Part 2 above supported? Explain your answer using evidence from the graph.*
   Based on this graph, the hypothesis and prediction appear to be supported because more animals were found in trail camera images in the savanna/woodland vegetation type than any other vegetation type. In order to determine whether the difference is significant, a statistical analysis (such as chi-square) would have to be performed.

11. *Which two variables did you compare?*
    Answers will vary.

12. *Describe the trends that you see in your graph.*
    Answers will vary.

13. *Based on this graph, are your hypothesis and prediction supported? Explain your answer using evidence from the graph.*
    Answers will vary.

14. *How is a prediction different than a hypothesis? Why do you think forming a prediction prior to analyzing data is important?*
    A hypothesis is a possible explanation for an observed phenomenon, which is based on additional observations or prior knowledge. A prediction is the expected results of your investigation if the hypothesis is supported. Forming a prediction prior to analyzing data is important because the prediction clearly defines which results will support the hypothesis. Making the prediction prior to data analysis reduces ambiguity and bias.

15. *What are the potential limitations of trail camera data? Identify at least two potential limitations or biases of trail camera data or the way the data are collected.*
    Answers will vary; however, some possible limitations and biases include:
    - **Trail cameras only take photos of animals that are large enough to be captured by the camera sensors. This technique omits smaller animals.**
    - **More photos are taken of animals that spend a lot of time in front of a camera as opposed to animals that pass by quickly.**
    - **Some individual animals visit the same area repeatedly, so individuals are counted multiple times.**
    - **When comparing across habitats, there may be a bias if some habitats have more cameras in them than others.**

- **Cameras in open habitats may detect animals in a larger area than habitats with dense vegetation.**

16. *In this activity, the scientific process followed a linear sequence: observation, question, hypothesis, prediction, and results. However, the process is typically iterative. Explain how new information might lead a researcher to go back and repeat certain steps in the scientific process, including asking different questions. At what stages in your process could you have obtained additional information from the scientific literature or other sources to inform or revise your process?*
    Answers will vary.

17. *Based on the results of this investigation, what are some additional research questions that you could ask?*
    Answers will vary.

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