SCIENTIFIC INQUIRY USING WILDCAM GORONGOSA

OVERVIEW

This activity complements WildCam Gorongosa (http://www.wildcamgorongosa.org), an online citizen science platform for identifying animals photographed by motion-detecting trail cameras in Gorongosa National Park. The WildCam Lab is a part of WildCam Gorongosa where students can view trail camera data on a map, filter, and download the data to investigate scientific questions.

In this activity, students will be guided through the development and investigation of a scientific question using trail camera data that they download from the WildCam Lab. Students will begin by viewing trail camera photos, making observations, and brainstorming questions. They will then explore a spreadsheet of trail camera data and identify a testable question that can be investigated using this data set. 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 the appropriate variables to analyze and graph data using a spreadsheet program.

This activity can be differentiated for students with different levels of prior experience with designing an investigation and analyzing data in spreadsheets. Parts 1 and 2 engage students with the practice of making observations and forming questions to get them oriented to scientific thinking. Parts 2 and 3 offer educators a chance to model the idea of testable questions, hypotheses, and predictions using a pre-defined question before they try with their own question. Part 4 offers an opportunity to demonstrate how data can be filtered in the WildCam Lab. A spreadsheet tutorial and examples are included to support educators and students with this activity.
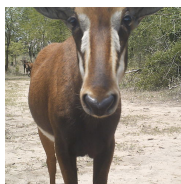
KEY CONCEPTS

- 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.

- Data can be analyzed to investigate scientific questions and to communicate findings.

LEARNING OBJECTIVES

Students will be able to:

- Develop testable ecological questions based on available data.

- Formulate hypotheses and predictions about the questions that they posed.

- Select and analyze data to investigate their questions.

- Communicate the results of their inquiry and generate new questions based on their findings.

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	HS-LS2-1, HS-LS2-2, HS-LS2-6, HS-LS2-8
Common Core (2010)	RST.9-12.7, WHST.9-12.7, HSS.IC.B.5, HSS.ID.B.5, MP.2
AP Biology (2012–13)	2.C.2, 2.D.1, 2.E.3, 3.E.1, 4.A.5, 4.A.6, 4.B.3
IB Biology (2016)	NOS 1.3, 1.6, 1.8; NOS 3.1, 3.2, 3.7, NOS 4.1, 4.2; HL & SL 4.1, 4.2; 5.3 HL Options A.6; C.1, C.4
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
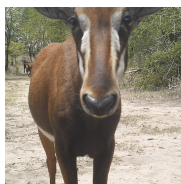
TIME REQUIREMENTS

Parts 1 through 3 can be completed in one 50-minute class period. Alternatively, Parts 1 and 2 could be assigned as homework prior to class if class time is limited and students have Internet access. Parts 4 through 6 can be completed in one to two additional 50-minute class periods depending on students' abilities with data analysis. Alternatively, part 6 can be assigned as homework.

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

- Students could be introduced to the WildCam Gorongosa website and perform some animal identifications prior to conducting this activity, either in class or as homework, to familiarize them with the trail camera project.
- Students could 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.
- Students could also watch the film "The Guide: A Biologist in Gorongosa" (http://www.hhmi.org/biointeractive/guide-biologist-gorongosa) to learn more about the history of Gorongosa and changes to the park's ecosystems over time.
- 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) prior to this activity would be beneficial but is not necessary.
- A spreadsheet tutorial is provided as part of this activity.

MATERIALS

- Printed copies of the student worksheet
- Computers for each student or group with an Internet connection, a web browser, and 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 the WildCam Lab website.
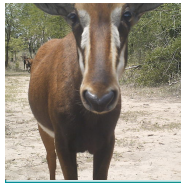
PROCEDURES

Prior to Class
- If you don't already have an account on Zooniverse, create one here: https://panoptes.zooniverse.org/users/sign_in
- Explore the WildCam Lab (https://lab.wildcamgorongosa.org) and create a new classroom. Copy the link and provide it to your students to invite them to join your classroom.
- Each student or group must have a computer with spreadsheet software and Internet access to use the WildCam Lab. Download the spreadsheet tutorial onto each of these computers.
- Print one student handout for each student or group.
- Depending on how you decide to work through the activity, you may want to have a projector connected to a computer to display the WildCam Lab and the spreadsheet tutorial.

Part 1: Making Observations and Asking Questions
1. Distribute the student handout and instruct students to read the introduction.
2. Instruct students to go to WildCam Gorongosa (www.wildcamgorongosa.org), create an account, and spend 10 minutes classifying photos, writing down observations and questions in question 2.
3. Before students continue to part 2, engage in a brief class discussion of students' observations and questions, highlighting how observations can lead to the development of scientific questions.

Part 2: Testable Questions
1. Instruct your students to read Part 2 of the handout and answer questions 3 and 4.
2. Before students complete question 5, engage in a discussion about the types of data that could be collected from the WildCam images as students might struggle initially see the images as a source of data.
3. Instruct students to complete question 5 that refers to the questions they developed in part 1, question 2.

Part 3: Hypothesis and Prediction
1. Instruct your students to read the part 3 of the handout and answer question 6 and 7. If this is the first time they are forming a hypothesis and prediction on their own, this may need further explanation.
2. Instruct your students to read about independent and dependent variables before they complete question 8. If this is the first time your students are encountering independent and dependent variables, discuss this topic further with some examples.
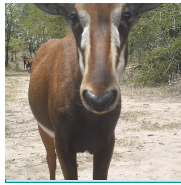
Part 4: Data Collection Plan
1. On the overhead projector, demonstrate how to filter and download data on the Data page of the WildCam Lab. Students should take notes as you demonstrate so they are ready to gather data using the portal. Make sure to include:
   a. How to select filters
   b. What to do with filters that are not necessary to answer your question (they should be left blank).
   c. Consider using the sample question from the student worksheet ("During which season is the highest abundance of animals present in the limestone gorge vegetation type?") to demonstrate how to choose filters that are appropriate. For this question, you would only need to select "Limestone Gorge" filter under habitat. All of the remaining filters are left blank.
2. Instruct your students to think about the filters they need to apply for their own question. In question 9, have students circle the appropriate filters on the WildCam Lab screenshot. Check for understanding before students move to step 10.
3. Instruct students to complete step 10 and download data to their computers.

Part 5: Data Analysis
1. Step 11 requires the spreadsheet tutorial. Instruct students to complete the tutorial (which works best with Excel, but can work with Google sheets or Numbers).
2. Instruct your students to answer question 12. It is possible this question will require more discussion to determine whether they have sufficient data to make a conclusion.

Part 6: Communicating your Findings
1. Instruct your students to answer questions 13 through 17. This section can be completed as homework if class time is limited. Question 14 requires students to analyze and interpret their data (NGSS Practice 3) as well as to construct an explanation using their evidence (NGSS Practice 8).
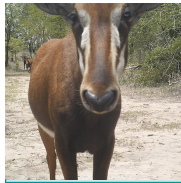
TEACHING TIPS

- 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, review the spreadsheet, and practice using the WildCam Lab. This review will be helpful for anticipating student questions during the actual lesson.
- The "Help" tab in the WildCam Lab includes some helpful tips and instructions for you and for your students.
- The Gorongosa Interactive map (http://www.hhmi.org/biointeractive/gorongosa-national-park-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. There are places in this activity that address these ideas, but reminding students frequently that science is an iterative and adaptable process is important.
- Students can complete this activity in partners, groups or individually. If students are working individually, they will likely benefit from the opportunity to discuss their ideas with others.
- While this activity is designed to illustrate scientific process, the questions can also address ecological concepts. The concepts learned in this activity can be revisited when the ecology unit is taught, or additional inquiry can be performed.
- The spreadsheet tutorial is recommended for use with Excel; 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.

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.

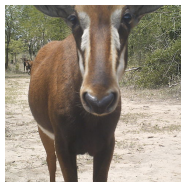**ANSWER KEY**

2. *Observations and questions about WildCam Gorongosa photos.*

Observations
Number of animals **Types of animals** **Behavior of animals** **Environment** **Abiotic and Biotic factors**
Questions
These will vary… some sample student questions are below (there aren't any "wrong" questions): • **Why aren't there any animals in some pictures?** • **Are there ever baboons by themselves, or are they always in groups?** • **What animals are common at night vs. during the day?** • **Are there more animals near the water?** • **What kinds of animals are usually together?** • **Why are there never any lions?!**

3. *With your partner, brainstorm which kinds of data you can gather from the trail camera photos.*
   Students will say lots of things here, but some possibilities include:

- **Numbers of animals**
- **Types of animals**
- **What the animals are doing**
- **Date**
- **Time of day**

4. *During which season is the highest abundance of animals present in the limestone gorge vegetation type?*

   Is this question testable using the data from the trail camera images? If so, what information would you include in your analysis from the images? If not, what additional data would you need to test this question?

   Yes, the question is testable using the trail camera images. You would need to include data the limestone gorge habitat. The variables that would be included in the analysis are the season and numbers of animals.

5. *Which questions from step 2 are potentially testable using the data below?*

   This will vary based on student questions. It is important to double-check what they consider testable before the next step.

6. *Of the questions you circled on your list in question 2 in Part 1, which one are you the most interested in studying?*

   Questions selected will vary.

7. *Based on the WildCam images you have seen so far, what is your hypothesis and prediction?*

   Hypotheses and predictions will vary depending on the student questions that are selected in question 6.
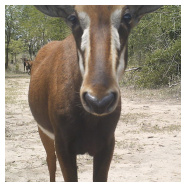
8. *Which variables from the spreadsheet will you need to include in your analysis to test your hypothesis (see the data columns in question 5)?*

   Answers will vary.

12. *Were you able to answer your question using the data you collected? If not, what additional data would you need to answer this question?*

   Answers will vary.

13. *Describe the trends that you see in your graph.*

Answers will vary.

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

Answers will vary.

15. *What are the potential limitations of trail camera data? Identify at least two potential biases of trail camera data or with the way the trail camera survey was designed.*
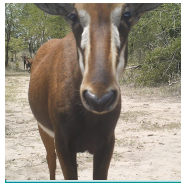
- **Trail cameras only take photos of animals that are large enough to be captured by the camera sensors. This technique omits smaller animals.**
- **More photos are taken of animals that spend a lot of time in front of a camera as opposed to animals that pass by quickly.**
- **Some individual animals 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, data collection/analysis, and findings. 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?*

At any point in an investigation, as new information is gained, a researcher might change their hypothesis or prediction. If they realize there isn't enough data to answer their question, they might revise or re-write their question. Prior to asking questions, researchers will obtain additional information so that their questions are novel, and testable. They will also do research to inform hypotheses and predictions in order to make them as accurate as possible. Finally, revisions will occur after data is collected. If the data is not sufficient to answer the initial question, new data may be collected or a new question may be formed.

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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