Title: Evolution in Darwin’s Finches: Using Darwin’s Theory of Evolution by Natural Selection postulates to evaluate evidence of evolution

One sentence description: Students evaluate evidence for evolution of Darwin’s finches using authentic research data sets collected by Peter and Rosemary Grant.

Description: In this activity students work with data sets collected by Peter and Rosemary Grant to investigate evidence for evolution in *Geospiza fortis* on Daphne Major, Galapagos. The first few minutes of the HHMI video “The origin of species: The beak of the Finch” is used to introduce the activity. Students begin by discussing changes in beak size on by evaluating a figure. They then work through what they would need to convince them that this figure represents evolution in the population using the postulates of Darwin’s Theory of Evolution by Natural Selection. Each group works with a data set that addresses one of Darwin’s postulates using authentic research data collected by Peter and Rosemary Grant (available through Dryad Repository). Each group generates a figure and conclusion as to whether the postulate is supported by the data. The activity culminates in a discussion of the evidence presented by each group and a final open-ended exploration into the selective pressure that could be driving changes in average beak size over time in the population of finches.

Modification: This activity uses a similar framework to the Evolution in Action: Data Analysis Finch activity from HHMI. A subset of the data set from the Evolution in Action activity is used as part of the postulate exploration. Much of the data set exploration incorporates recently published datasets from Peter and Rosemary Grant’s “40 Years of Evolution” freely available from Dryad Repository (<https://datadryad.org/>). The majority of the activity is unique from existing HHMI resources, but related through the theme of Finch Evolution.

Class setting:

* Course: General Biology – first, year introductory course for biology majors
* Timing: Activity was implemented in recitation (1hr 20 minutes)
* Students need: Access to data files and Excel (can be easily modified to GoogleSheets)

Skill development:

* Analyze and interpret figures
* Manipulating data sets using Excel
* Create figures and generate conclusions
* Evaluate evidence for evolution using data analysis

Teacher instructions:

Pre-exercise preparation: Have students review Excel using a modified version of the HHMI tutorials and complete pre-assessment before class.

Part A: Introduce Finch background and discuss Darwin’s postulates

Rather than writing a lot of detail about the Finch system in the activity worksheet I used the first three minutes of the HHMI video “The origin of species: The beak of the Finch” (<http://www.hhmi.org/biointeractive/origin-species-beak-finch>) to provide background about the Finches. I encouraged students to watch the rest of the video after the activity. We then had a group discussion about changes in beak depth observed by Peter and Rosemary Grant (see Figure 1 on the student worksheet). Students first interpret the figure and then think about whether or not they would say that the population definitely evolved between 1973 and 2013. This leads into a discussion about evaluating evidence for evolution using Darwin’s postulates. Through class discussion we identify, define, and discuss the four postulates. Student take notes on their Student Worksheet. They will need to refer to the postulates during later aspects of the activity.

Part B: Student exploration into data sets to evaluate support for Darwin’s postulates

To evaluate evidence of evolution following Darwin’s postulates students break up into groups of 2-4 to investigate a data set that applies to either postulates 1,2 or 4. I chose not to include postulate 3 (many more are born than survive) because we discussed how this is ubiquitous in nature during the class discussion. Postulate 4 is broken up into determining average beak depth in individuals that survived the drought and those that did not survive the drought. Each group should download the data set specific to their postulate. In each Excel file there is a ‘Data set’ tab with raw data and an ‘Instructions’ tab that will guide students through investigations with their data set. There are questions to facilitate the discussion embedded within the ‘Instructions’ tab.

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| **Postulate:** | **Data set description:** | **What students are doing:** |
| #1: Phenotypic variation exists in the population | In this dataset the Grants present data on the variation in beak depth (mm) in *Geospiza fortis* on Daphne major in 1977, 1989, and 2004. They categorized beak depth into 10 size classes (7.1-7.5mm, 7.6-8.0mm, and so on). The values represent counts of birds that have a beak depth that falls into that size class. | * Manipulate data sets
* Justify graph choices
* Create a bar graph
* Identify and label axes
* Generate a scientific conclusion from figure
 |
| #2: That variation is heritable | To assess heritability of a trait, you can compare similarity of a trait between the parents and offspring. Here the Grants compare beak depth in *Geospiza fortis* families on Daphne Major. The Mid-parent beak depth (mm) is the average beak depth between the parents of the offspring, and the Mid-offspring beak depth (mm) is the average beak depth of the offspring. A correlation between mid-parent and mid-offspring beak depth suggests that the trait is heritable and that genetics contributes to the trait variation. | * Manipulate data sets
* Justify graph choices
* Create a scatter plot
* Identify and label axes
* Add and interpret trendlines
* Generate a scientific conclusion from figure
 |
| #4a: Survival and reproduction is non-random (non-surviving population) | As the Grants continued to survey *G. fortis* throughout the 1970s they noticed that the population was changing. Between 1976 and 1977 a large number of birds died. Because of the Grant’s detailed and extensive surveys they were able to compare the average beak depth of the birds that survived past 1977 to those that did not survive. Thus, they could examine evidence of non-random survival with respect to bird beak depth. Here you will describe basic characteristics of the population of *G. fortis* that did not survive past 1977. | * Manipulate data sets
* Use formulas to make calculations
* Justify graph choices
* Create a histogram
* Identify and label axes
* Generate a scientific conclusion from figure
 |
| #4b: Survival and reproduction is non-random (surviving population) | As the Grants continued to survey G. fortis throughout the 1970s they noticed that the population was changing. Between 1976 and 1977 a large number of birds died. Because of the Grant’s detailed and extensive surveys they were able to compare the average beak depth of the birds that survived past 1977 to those that did not survive. Thus, they could examine evidence of non-random survival with respect to bird beak depth. Here you will describe basic characteristics of the population of G. fortis that did survive past 1977. | * Manipulate data sets
* Use formulas to make calculations
* Justify graph choices
* Create a histogram
* Identify and label axes
* Generate a scientific conclusion from figure
 |

Part C: Group discussion about evidence gathered and generated by the student explorations in Part B.

Students will submit their figures and conclusions at the end of Part B. I recommend copying them into powerpoint to facilitate discussion in Part C. Here you can have each group report out there conclusions to facilitate discussion. Alternatively, you can simply put the figure up and have the class as a whole generate the conclusions, and then ask the individual groups that worked with that data set if they have anything to add to the discussion.

Part D: Deeper investigations into Postulate #4 and beyond

This aspect of the activity further investigates Postulate #4: Survival and reproduction is non-random. Figure 2 on the Student Worksheet provides a summary of changes in beak depth between 1975 and 1979, which targets changes in beak depth around the 1976/1977 drought. Students interpret the figure and relate the changes to patterns of evolution (concepts that they are currently discussing in class). Students should relate the patterns observed in Figure 2 with Directional selection. They can then generate a hypothesis about the selective pressure that is driving the changes in beak depth. We had a brief discussion about why a drought might correlate with changes in beak depth. Students then go back to a data set that includes environmental variables in addition to beak depth. They can then play with the data set to generate figures related to their hypotheses. This data set is an aggregate from multiple data sets from the “40 years…” book. Note that this data set has possible figures on the second tab. I recommend removing this from the student version that you post.

The activity culminates in a group discussion of what they learned from the Finch data sets. They relate concepts of evolution and genetics to the evolution of beak depth in the Finches by relating their investigations with authentic research data to classroom concepts.

Reference:

Grant, PR, Grant, BR (2014) 40 years of evolution: Darwin's finches on Daphne Major Island. Princeton: Princeton University Press. http://www.worldcat.org/oclc/854285415

Grant PR, Grant BR (2014) Data from: 40 years of evolution. Darwin's finches on Daphne Major Island. Dryad Digital Repository. https://doi.org/10.5061/dryad.g6g3h