TheCornellLab of Ornithology

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Instructor Guide: Species Concepts in Birds

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Introduction

Purpose

By examining plumage and vocalization differences in pairs of bird species using multimedia from the Macaulay Library, students consider and discuss the practical implications of defining a species.

Overview

As a class, watch video from the Macaulay Library (http://macaulaylibrary.org) of Eastern and Western Meadowlarks and Blue- and Golden-Winged Warblers and discuss the fact that one pair of species hybridizes freely while the other does not. Students will then break into groups, with half the students examining the vocalizations of the meadowlarks and half examining the vocalizations of the warblers. After determining whether they think their species pair is likely to be the one that hybridizes, the groups will reconvene to discuss their findings and to discuss the implications for their results for how we understand species concepts.

Essential Questions

What is a species?
What are the practical implications of the species definitions we choose?

Learning Objectives

Students will be able to:

- Explain the difficulties of defining a species.
- Describe some potential conservation implications of the ways species are technically defined.
- Describe the role of song in mate selection. Explain why characteristics of sound would have the potential to allow species to either hybridize or be behaviorally reproductively isolated.
- Be able to interpret a spectrogram (or sonogram) view of sound.
- Define and measure quantitative traits in bird song.

Extensions:

- Evaluate multiple sources of data and weigh conflicting definitions to develop a coherent argument based on theory and evidence.
- Conduct basic statistical analyses and create graphs

Materials

Computers (one per student group) with Firefox browser and QuickTime, RavenViewer plug-in, and Flash player pre-installed
Internet access
Projector
1 pair of speakers (to play videos for class)
Student Sheets (best printed in color)
RavenViewer At-A-Glance guide (best printed in color)
Powerpoint slides introducing the Macaulay Library (provided)
Optional:
Earbuds for each student group (if noise from multiple groups is a concern)
Access to the Birds of North America Online website (small cost)

Setting

This investigation is intended for introductory courses for majors or non-majors, as well as upper-level Evolution, Ecology or Conservation courses. It could be used as a laboratory or recitation activity, as well as in longer lecture periods.

Preparation

The data analysis and interpretation for this investigation hinge on students having some understanding of the variety of species concepts that exist, as well as the concept of reproductive isolation. While the initial discussion asks students to define a species in their own words, if this is the first time species concepts have been introduced, you may want to allow extra time for discussion. A possible pre-lab activity would be to assign students to a jigsaw (see: http://www.esa.org/tiee/teach/tutorials/jigsaw.html), where each group is responsible for becoming the expert on a different species concept or isolating mechanism and then teaching their classmates about it.

The instructor should be familiar with some of the basic background information on the species of birds being considered. If your institution's library has access, you could consult the relevant species accounts on the Birds of North America Online site: http://birds.cornell.edu/bna.

The more familiar the instructor is with sound visualization and analysis, the easier it will be to help troubleshoot with the various student groups during the data collection period. For information on how to download the free RavenViewer plug-in for QuickTime, as well as helpful guides to interpreting sound visualizations, please see: http://macaulaylibrary.org/help/ravenViewer/index.do.

If desired, an inquiry-based pre-lab activity could be used to familiarize students with looking at and interpreting sound spectrograms. See http://birds.cornell.edu/orb/investigations for ideas. You may wish to ask the students to explore Macaulay Library and install RavenViewer software on their laptops before coming to class. Alternatively, you could use the provided PowerPoint to give a brief introduction to the Macaulay Library and the visual representation of sound.

Time

This investigation will take approximately two-and-a-half hours of in-class time, best done in a computer lab with a white board and projector to facilitate both whole class discussion and individual work.

If students have not worked with sound spectrograms before, extra time may be required for them to develop their spectrogram skills.

Depending on the level of interpretation and writing assigned, this module take could 9+ hours of total student time. An estimate of the various parts follows:

Prelab (Optional):
- Pre-lab activity on sound analysis (30-45 min)
- Jigsaw on species concepts and reproductive isolation (30-45 min)

1-1.5 hours

In class:
- Introductory discussion and engagement (30-45 min)
- Exploration and measurement (45-90 min)
- Collecting class data and debriefing (30 min)

2-3.5 hours

In or out of class:
- Answering discussion questions individually or as a group (30 min)
- Data analysis and graphing (1-1.5 hours)

1.5-2 hours

Extensions/Out-of-class (Optional):
- Selecting and measuring additional species (45-90 min)
- Researching descriptions of the species' song, behavior, morphology, and ranges or species concepts (1 hour)
- Writing a scientific report (3-5 hours)

5-7.5 hours

Total time = 9.5-14.5 hours

Extension(s)

1. You may wish to have students investigate the natural history and breeding ranges of the species in greater detail in the authoritative species accounts in the Birds of North America Online. It might be particularly illuminating to review the sections on song and hybridization for the Golden-winged Warbler and the Blue-winged Warbler.

2. Students could be assigned to write a longer-form lab report, creating graphs of

their data and doing basic statistical analyses (e.g., a t-test reporting p-value). See Assessment for more ideas on evaluating these reports.

3. This investigation could easily fit in with other lessons using the Macaulay Library and Raven sound analysis software. You could assign or have students choose other pairs of species, both ones that *do* hybridize, and ones that *don't*, to conduct additional analyses.

   In doing so, it may be helpful to consult this list of North American bird hybrids (but please note that some of the Latin names are out of date):
   http://elibrary.unm.edu/sora/Wilson/v064n03/p0140-p0159.pdf

   Here are some additional species pairs that *do* hybridize:
   Black-capped and Carolina Chickadee
   Tufted and Black-crested Titmouse
   Bullock's and Baltimore Oriole
   Lazuli and Indigo Bunting

   For non-hybridizing pairs, it might be good to ask the students what they think the most powerful comparison would be, and have them chose the non-hybridizing species to analyze.

   The best approach would likely be to chose another member of the same genus for each of the above species pairs, since that would reduce the number of species that needs to be measured and also would make the comparison cleaner.

4. Students could read a paper dealing with the practical/conservation sides of defining species to prepare for arguing an (assigned position) in a class debate following this activity. See Assessment for examples of follow-up questions relevant to the nature of science or conservation implications.

5. Students could read about and the class could discuss the "universal species concept" (de Queiroz 2007) as a means of building a stronger case for species definitions on the basis of multiple lines of evidence.

Procedure

1. Probe the students' prior knowledge by asking them to define "species."

2. Engage the students' interest by showing four videos from the Macaulay Library's online archive.

   First Pair:
   http://macaulaylibrary.org/video/flashPlayer.do?id=15063
   http://macaulaylibrary.org/video/flashPlayer.do?id=35410

Second Pair:
http://macaulaylibrary.org/video/flashPlayer.do?id=36872
http://macaulaylibrary.org/video/flashPlayer.do?id=35383

All four individuals are currently recognized as belonging to different species (Eastern and Western Meadowlarks, and Blue-winged and Golden-winged Warblers). Ask the students to predict which species pair they think hybridizes and which pair does not, with the idea that the "good" species should not hybridize. Ask the students what other information they might need to know to make an accurate prediction.

The warblers readily hybridize, although their appearances are very distinct, while the meadowlarks look very similar but are completely reproductively isolated. Both sets have distinct songs. (More information on the reproductive isolation of the meadowlarks and the hybridization of the warblers is available from the Birds of North America website, http://birds.cornell.edu/bna.) Other information that may be valuable in making predictions about potential selective pressures on these species includes the location of their breeding ranges.)

3. Ask the students to split in to two groups to quantify differences in the songs of either the meadowlark pair or the warbler pair (see Student Sheets). Note: it may be helpful to do a demonstration of RavenViewer before the students break into groups.

4. Re-convene the class and ask again which birds should be categorized as different species or not and why. Ask the students whether they think their hypothesis was supported or not from a preliminary investigation of the data. If they think their hypothesis was supported, help them describe additional graphs and statistical tests that could be used to show a statically significant finding. If their hypothesis was not supported, ask them to speculate on why not, and what other factors they might want to take into account. If the data were inconclusive, discuss the concept of sample size and repeatability.

5. Finally, see Assessment section for ideas on hosting an engaging class discussion on why the species concept matters. Depending on the type of course, you might wish to ask the students to reflect further on their research methods or on the conservation implications of the species concept.

Assessment

1. To conclude the investigation, discuss as a class why the species concept is important.

If one of the main goals of modern biology is to understand and organize the diversity of living things, then the species is one of our most successful ideas. Given a species' name, we can usually make an accurate description of an organism's morphology, communication systems, habitat preferences, and mode of acquiring energy. From a more practical level, the species

concept is also important because most conservation legislation is written for species. It is therefore critical from both a theoretical and a conservation perspective to be able to define a species—which is a complicated task, as evidenced by the diversity of species concepts that have been proposed.

2. You might also wish to have students discuss the appropriateness of species-based conservation legislation. Some ideas for discussion:

- Are any groups that have distinguishable phenotypes worthy of conservation?
- What about something like the California Gnatcatcher, where the forms are distinguishable based on the proportion of white coloration on the outermost tail feathers (e.g., Zink et al. 2000)?
- Is DNA the answer, and should only species that are reciprocally monophyletic be conserved?
- Or, given the length of time that may be necessary for reciprocal monophyly to evolve, should phenotypes be considered?

3. As homework or an extension activity, you could ask students to think about potential flaws in the design of their investigation methods, as if they were to be submitting a manuscript for publication using similar methods. Students could also explain their methods to another group and then peer review and give constructive feedback, particularly if you plan to have them investigate additional species pairs on their own.

For instance, measurements were probably not taken blind with respect to species identity; possible geographic variation in song was probably not considered; and comparing measurements from two different groups of students may not be appropriate, depending on how standardized the measurements were.

4. If you assigned students to write a longer-form report on the results of their investigations, it is a good idea to provide a grading rubric or examples of desired outcomes. For examples, please contact the authors at: http://www.birds.cornell.edu/orb/contact. Students could also play a role in designing this rubric or in peer-reviewing one another's reports before they are due to the instructor.

Suggested Additional Readings

Atwood, JL. 1988. Speciation and geographic variation in black-tailed gnatcatchers. *Ornithological Monographs 42.* Available at: http://elibrary.unm.edu/sora/om/om042.pdf

de Queiroz, 2007. Species concepts and species delimitation. *Systematic Biology 56*(6): 879-886.

Zink, RM, GF Barrowclough, JL Atwood, and RC Blackwell-Rago. 2000. Genetics, taxonomy, and conservation of the threatened California gnatcatcher. *Conservation Biology 14*(5): 1394-1405.