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CourseSource

Lesson

A Modeling Exercise in Sexual Selection using a Student-Created Bird Species

Ashley B. Heim[1,2*], Anna Freundlich[2], and Emily A. Holt[2]

[1]Ecology and Evolutionary Biology, Cornell University (current affiliation)

[2]School of Biological Sciences, University of Northern Colorado

Abstract

Evolution-centered lessons at the undergraduate level can often be jargon-heavy, propagate misconceptions if taught ineffectively, and be uninteresting to students who may not see the relevancy of such concepts. This activity provides a fun and hands-on way for introductory biology students to learn about sexual selection and fitness and encourages students to consider what traits the "flashier" sex may use to attract the "less flashy" sex and how sexual selection and fitness are related. In this activity, after reading a short scenario, half of the students in the class are assigned as "flashy birds" and required to create a model of a flashy bird (of a fictitious species) that they believe will attract the less flashy sex of this same species using materials (e.g., modeling dough and other craft materials). The other half of the students are assigned as "less flashy birds" and required to compile a list of traits and behaviors that they would prefer to see in their flashier counterparts. Once modeling is complete, students in "flashy bird" groups are asked to share the birds they created at the front of the class and justify why they gave their individuals particular characteristics and behaviors. Students in the less flashy bird groups then "vote" on which flashy bird they prefer given its unique traits, based on the lists they compiled of desired characteristics. This is a highly student-centered activity which can be easily adapted to meet the needs of your students, your learning goals and objectives, and your curriculum.

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Supporting Materials: Supporting Files S1. Modeling Exercise in Sexual Selection - Lesson Timeline; S2. Modeling Exercise in Sexual Selection - Powerpoint Slides; S3. Modeling Exercise in Sexual Selection - Handout & Answer Key; S4. Modeling Exercise in Sexual Selection - Sample Exam Questions; and S5. Modeling Exercise in Sexual Selection - Sample Bird Model/Trait List Rubric.

***Correspondence to:** Ecology & Evolutionary Biology, Cornell University, Ithaca, NY, 14853, USA. Email: abh229@cornell.edu

Learning Goals

Students will understand:

- the process of sexual selection, including what characteristics of a species could be selected for to attract mates.
- how sexual selection and fitness are related.

Learning Objectives

By the end of this activity, students will be able to:

- model and summarize the purpose of intersexual selection.
- describe and justify which traits and behaviors of species could increase fitness of individual offspring in subsequent generations within a given environment.
- explain why the "flashier" sex tends to have seemingly non-adaptive ornamentation across animal species.
- discuss why "less flashy" individuals of species that undergo sexual selection need to be "choosy" when deciding on mates, and list the potential direct and indirect benefits of choosing a mate with good traits and high fitness.

INTRODUCTION

Prior to Spring 2019, the lead author (AH) had only taught students majoring in biology, and found that these students tended to be motivated by a variety of biology topics—from the cellular to organismal level—because they saw the relevance and practicality of such topics in their future careers or daily lives. However, in Spring 2019, AH had her first experience instructing non-majors in an introductory biology course—from students majoring in theater to criminal justice—and she was anxious to develop lessons that were relevant, engaging, and motivating. For most students in this non-majors course, this was not just the only *biology* class they would have to take in college, but the only *science* class they were required to enroll in for their degree program. So, how could she transform topics that students outside of biology may find mundane into exciting and fun student-centered lessons that incorporated active learning practices? Although motivating non-majors students across a range of degree programs to learn biology was a challenge throughout the semester, AH had heard anecdotally from previous instructors of the same course that evolution tended to be a misconceived and jargon-heavy topic for non-majors students; it was often difficult for these students to find evolutionary topics such as natural or sexual selection relevant to their everyday lives.

Sexual selection can be defined as a form of natural selection which promotes traits that help organisms acquire mates. An important concept related to sexual selection is differential reproductive success, the idea that individuals with certain characteristics survive better and produce more offspring than individuals with alternative characteristics (1). While intrasexual competition is defined by competition between members of the same sex (e.g., fighting), intersexual selection broadly includes mate choice by members of opposite sexes (e.g., coloration, mating rituals, or songs to attract mates). For background about evolutionary mechanisms—including sexual selection—most introductory biology textbooks provide a sufficient level of detail for teaching this lesson (e.g., The Tangled Bank by Carl Zimmer (1)). However, more detailed reviews on sexual selection concepts are also available on this topic (2-3), as are teaching modules focused specifically on sex- and gender-related topics in biology (e.g., sexual reproduction, determination, dimorphism, and selection) from Project Biodiversify.

While Moore et al. (4) published a game on sexual selection and reproductive behaviors (including focusing more on how differences in gamete size relate to parental investment), their activity is geared more towards higher-level animal behavior topics and majors-biology undergraduates. In addition, their game centers on outdated explanations of Bateman's Principle, that reproductive variance is greater in males than females and that females invest more energy into producing offspring (5); this principle has come under intense scrutiny in recent years for perpetuating inaccuracies (e.g., sperm is cheap, females are always the choosy and passive sex (6)) For a more complete review of the inconsistencies associated with Bateman's Principle, see Testosterone Rex by Cordelia Fine (7).

AH wanted to be sure that our activity on sexual selection was engaging, fun, and allowed students to appreciate the relevancy of such concepts. Co-author AF had served as an in-lecture graduate teaching assistant for this same course in a previous semester, and first developed the sexual selection activity outlined in this manuscript as a way to both increase student participation in a high-enrollment lecture and grant students the opportunity to be creative and goofy while learning about concepts like mate choice and fitness.

The first running of the sexual selection activity was an overwhelming hit! Students seemed to genuinely enjoy themselves as they created models of flashy birds and lists of characteristics that less flashy birds prefer in a mate. In contrast to small group or pair activities, this activity allowed students to interact and connect with the class as a whole. Many students even mentioned at the end of the semester that it was the most memorable part of the class for them, and that they still remembered the basic concepts of sexual selection because of it.

The teaching and learning strategies included in this lesson are based on evidence-based teaching approaches. Physical, hands-on modeling in STEM courses can improve student comprehension of abstract ideas and simplify challenging concepts (8) as well as provide an opportunity to apply scientific knowledge in creative ways (9). In our lesson, students have an opportunity to generate (or critique) a physical bird model during which they can visualize more challenging, abstract concepts of sexual selection using simple, hands-on methods. Some published CourseSource lessons have also used physical modeling as an effective strategy for learning biology (e.g., 10-12). Further, brainstorming—which we ask our less flashy bird groups to engage in when compiling lists of preferred mate traits and explaining their responses—may promote critical thinking among students (13-14). Additionally, our lesson is founded on collaborative group work and peer feedback, strategies which often offer opportunities for low-stakes, formative assessment and comprehension (15).

We should also note that in this lesson, we use the terms "flashy" birds to indicate bird sexes characterized by more coloration, distinct patterns, and complicated song and mating rituals, and "less flashy birds" to indicate bird sexes that have more subdued coloration, less vibrant patterns, and simpler (or no) song and mating rituals. As male bird species will generally be flashier when females are choosing (e.g., peacocks, cardinals), and female bird species will generally be flashier when males are choosing (e.g., jacanas, sandpipers), we wanted to avoid supporting misconceptions related to heteronormative behaviors during sexual selection (4-8). While you can discuss this topic during lectures preceding this lesson, we have also included a brief summary of why we use the terms "flashy" and "less flashy" birds on the student activity handout.

Intended Audience

This activity was developed for an **introductory non-majors biology course** (with 150 students) at a medium-sized regional university, but could also be used in introductory majors biology or evolution courses.

Required Learning Time

50-60 minutes

Prerequisite Student Knowledge

Prior to implementing this activity in class, students were required to read the corresponding "mechanisms of evolution" chapter in their textbooks, as well as complete an online homework assignment based on the same material; while we used the pre-established homework assignment provided by the textbook company, any general reading and homework assignments on mechanisms of evolution should suffice. We also completed this activity after spending an entire 50-minute lecture period on mechanisms of evolution, including natural selection and sexual selection. Learning objectives for the aforementioned mechanisms of evolution lecture, textbook reading, and online homework assignment suggested that by completion of the lesson, students should be able to:

1. Explain the relationship between evolution, allele frequencies, and populations.
2. Summarize the evidence Darwin and Wallace used to develop their theories of evolution by natural selection.
3. Explain the link between natural selection and reproductive success.
4. Explain how natural selection can affect allele frequencies.
5. Discuss how natural selection can maintain harmful alleles in a population.
6. Explain how sexual selection can promote traits that seem to decrease survival. Provide some examples of sexual selection.
7. Compare and contrast how mutation, genetic drift, nonrandom mating, and migration (i.e., mechanisms of evolution) contribute to evolution.

8. Explain why flashier sexes tend to have seemingly non-adaptive ornamentation.

Prerequisite Teacher Knowledge

Instructors should be familiar with the *basics* of mechanisms of evolution (i.e., natural selection, genetic drift, migration, mutations, non-random mating), and specifically inter-sexual selection, as this activity was designed for non-majors introductory students.

SCIENTIFIC TEACHING THEMES

Active Learning

- *Activities outside of class*: If students do not have sufficient time to complete all of the follow-up short answer questions at the end of the modeling activity, the instructor can opt to have students complete this assessment for homework.
- *Activities in class:* Small group and classroom-wide discussion, collaboration, and modeling.

Assessment

- *Preassessments*: None, excepting if students have a general homework assignment related to their textbook reading on mechanisms of evolution (specifically, natural selection and sexual selection).
- *Postassessments*: Answer short answer questions about sexual selection in class or for homework; answer multiple choice questions on unit lecture exam related to sexual selection concepts.

Inclusive Teaching

- In this lesson, we use the terms "flashy" birds to indicate bird sexes characterized by more coloration, distinct patterns, and complicated song and mating rituals, and "less flashy birds" to indicate bird sexes that have more subdued coloration, less vibrant patterns, and simpler (or no) song and mating rituals. While male birds are often flashier than females, we wanted to emphasize to students that not all bird species follow this trend (e.g., species in which the females tend to have more influence or choice during the mating process) and to avoid supporting misconceptions related to heteronormative behaviors during sexual selection (4-8).
- This activity has the potential to engage many students, as students tend to be interested in organisms they encounter or observe in their daily lives (e.g., birds).
- This lesson encompasses a variety of learning modalities in which students are required to use multiple senses to accomplish tasks, such as creating flashy birds out of modeling dough as well as oral and visual sharing of models at the end of the class period.
- This activity requires students to collaborate in both small groups and as a whole class, so there is also the potential that students will form novel connections with their peers during the lesson.

LESSON PLAN

This lesson could be implemented over several class sessions or shortened, depending on the needs of the instructor. However, the entire lesson described here requires approximately 50-60 minutes and encompasses *only* the sexual selection activity; an associated lecture on mechanisms of evolution should have been presented to students in the preceding 50-minute class period. A teaching timeline with options, the sexual selection lecture slides (along with useful web-based resources in the Notes section), and the sexual selection activity handout are included as separate documents (S1. Modeling Exercise in Sexual Selection - Lesson Timeline; S2. Modeling Exercise in Sexual Selection - Powerpoint Slides; S3. Modeling Exercise in Sexual Selection – Handout & Answer Key).

Before Class

Teacher preparation

To implement this activity, instructors should have a foundational understanding of the mechanisms of evolution (i.e., natural selection, genetic drift, migration, mutations, non-random mating), and specifically inter-sexual selection. We found the simplest and most convenient means of reviewing this information was by reading the relevant evolution chapters in our course textbook, although any introductory biology or evolution textbook should be sufficient. Hosken and House (2) and Brennan (3) provide succinct and informative reviews and list further readings at the end of their publications. Additionally, teaching modules focused specifically on sex- and gender-related topics in biology (e.g., sexual reproduction, determination, dimorphism, and selection) are available as additional pedagogical resources from Project Biodiversify.

You will need to prepare lecture slides based on how much detail students should know about sexual selection concepts. Keep in mind that we presented these slides in the class period preceding the sexual selection activity as part of a larger lecture, though here we included only the slides relevant to sexual selection (S2. Modeling Exercise in Sexual Selection - Powerpoint Slides).

You will also need to make copies of the accompanying activity handout for each student in your class, which is available in the Supporting Materials provided with this lesson.

Lastly, since this is a modeling activity, you will need to ensure that you have enough modeling dough available for your students. At the very least, each student group should have one 1-ounce container of modeling dough (which they can bring back to their seats), though we recommend having much more dough available in case students want to incorporate multiple colors into their bird models; we have several larger tubs of dough available at the front of the class for student use. Additionally, we have a variety of craft materials at the front of the class, including pom-poms, googley eyes, pipe cleaners, and stickers, that students can use to create their bird models, although any craft materials that allow students to showcase their creativity can be used (depending on logistics such as cost or availability of materials). As students assigned to the less flashy bird groups will be directed to share with the class one or two traits they would prefer in a mate, you also need to consider how you would like to organize this portion of the activity. In our class, students in the less flashy bird groups were directed to add one or two characteristics to a bulleted list on a Word document that was later projected at the front of the classroom (after modeling was completed). However, you could also instruct students to add their characteristics to a large poster hanging at the front of the classroom, or to a whiteboard or chalkboard. We did not have any issues with students from

the flashy bird groups trying to listen in or peek at the traits compiled by the less flashy bird groups, but be aware that you may need to limit access to these lists to only less flashy bird groups until the end of class (so that students in the flashy bird group do not gain an unfair advantage by knowing what traits their counterparts are looking for in mates).

Student preparation

Aside from ensuring that students have sufficient background knowledge on natural and sexual selection via lecture slides, textbook reading, and/or homework assignments associated with the textbook reading, there is no additional preparation for this activity.

During Class

Introducing the activity (~5 minutes)

Before students get started on the activity, you need to instruct them to form groups of 2-4 or to join their regular group members if student groups are pre-established in your class. (We do not recommend groups of more than 4 students, as this limits participation among individuals and can make communication more difficult, especially if this activity is being implemented in a large lecture hall.) Next, you should pass out one copy of the activity handout to each student so that each individual can read the scenario and activity guidelines, even though students are working in groups. You can either opt to read the Introductory Scenario and Exercise Overview from the handout to the class, or you can give approximately 2-3 minutes for students to read through the scenario individually or in groups.

A Modeling Exercise in Avian Sexual Selection (~25 minutes)

After students have read through the Introductory Scenario and Exercise Overview in their handouts, you will need to assign approximately half of the class as "less flashy birds" and the remaining half of the class as "flashy birds." In our large 150-student lecture, we found it easiest to draw an imaginary line down the middle of the classroom and assign student groups on the left side as less flashy and on the right side as their flashy counterparts. However, allocating bird roles can be adapted to fit the size of your class. For example, if your students are in groups of 4, you could also have 2 students in each group volunteer to be flashy birds and the remaining 2 students in the group volunteer to be less flashy birds.

Once students have been assigned their bird roles, direct them to read through the Exercise Guidelines in their handouts. You will most likely need to remind students in the flashy bird groups to "plan out" their bird model prior to collecting the necessary materials (e.g., modeling dough, pom-poms, pipe cleaners, etc.) at the front of the class; this not only promotes brainstorming among students but also prevents students from taking more materials than they need for the activity.

You should inform students in the less flashy bird groups that they should share their preferred mate characteristics after developing a list in their groups, by the method you decide is best for your class (e.g., shared Google Document, poster, whiteboard, etc.). In addition to prompting students to complete the four questions on page 2 of the handout (sample responses are provided in S3. Modeling Exercise in Sexual Selection - Handout & Answer Key), we remind students intermittently how much time is remaining to complete the activity. Additionally, we found it helpful to walk around the class and ask groups to justify why they had included certain traits in their models or on their lists during the activity, or to answer any questions that students still had about the topic of sexual selection.

During our lesson, flashy bird groups developed models with diverse physical traits. For example, many groups used brightly colored modeling dough and added several ornaments (e.g., pom-poms, pipe cleaners, stickers) to their bird models. (Some students even added their own personal jewelry to further decorate their birds!) Additionally, many groups also crafted elongated feathers or larger bodies for their models. Regarding behavioral characteristics, most flashy groups also developed some sort of ritualistic dance and/or unique vocalization that they would use to attract mates; flashy groups displayed these behaviors when sharing their bird models at the end of the activity.

Less flashy bird groups in our class compiled detailed lists of traits that they would prefer in their flashier counterparts. Common examples included colorful feathers, bills, and feet, iridescence, long feathers, large wingspans, attractive mating dances, loud vocalizations that were pleasing to the ear, and elaborate and well-built nests. We should note that students in both groups often mentioned selection pressures from predators, though this was not their primary focus when discussing sexually-selected traits in either group. Further, students sometimes asked questions to supplement the background information provided in the handout prompt (e.g., considering what the predators and herbivores might look like, and how they might interact with the local bird species), but did not generally ask questions to clarify sexual selection concepts.

Wrapping up the activity (~20 minutes)

Once the flashy and less flashy bird groups have completed their assigned portions of the activity, you instruct one member of each flashy bird group to stand shoulder-to-shoulder at the front of the class with their bird models. The logistics of sharing models will completely depend on the size and needs of your class, so feel free to adapt this part of the activity in any way that you see fit! In our class, students took turns placing their bird models on a document camera that was projected at the front of the class and briefly described the prominent traits of their birds in approximately 20-30 seconds. After presenting their bird models to the rest of the class, these student volunteers were instructed to remain standing shoulder-to-shoulder at the front of the class. After all groups had shared their flashy bird models, we then projected the list of preferred mate characteristics that students in the less flashy bird groups had compiled during the activity. We gave students approximately 30 seconds to read through the projected list and think about whether the traits of the presented flashy birds aligned with the traits that their counterparts preferred; then, one to two volunteers were asked to comment on this alignment and relate it back to sexual selection and fitness.

Finally, have each student presenting a flashy bird model hold up their birds for a few seconds, one student after another. During the few seconds when each bird is being held up to the audience, instruct students in the less flashy bird groups to vote on their preferred models; this decision should be based on the list of preferred traits compiled by each less flashy bird group in relation to how well these traits aligned with the flashy bird models presented. In our class, less flashy bird group members

informally voted by clapping and cheering for their preferred bird models, although you could also instruct students to formally vote on their preferred birds via some sort of survey or tally system. Additionally, you should require students from the less flashy bird groups to explain how the overall fitness of the flashy bird models influenced their mate decisions (e.g., what characteristics of the flashy birds could potentially lead to increased fitness?). We allowed students to vote for up to three bird models (since our class was so large), but this decision is up to you; you can just as easily require students to vote for a single model.

Depending on how long the activity takes, your students may have time in class to complete the three post-activity questions on the last page of the handout. However, you can also assign these questions as homework, if you run out of time. Sample responses for the post-activity questions are provided in S3 - Modeling Exercise in Sexual Selection - Handout & Answer Key. Keep in mind that clean up for this activity can also take several minutes, as students need to return their borrowed materials and turn in their handouts if you are collecting these assessments.

TEACHING DISCUSSION

Achieving the Activity Learning Goals and Objectives

The original learning goals of this activity were designed to increase students' understanding of sexual selection and fitness, and we believe this lesson not only achieves these goals but does so in a way that students find entertaining and engaging. Further, students put great effort into designing their models and compiling their lists of preferred traits and seemed to genuinely enjoy sharing their models and choosing the "best" flashy bird individuals at the end of the activity. We think as students compare the list of traits preferred by less flashy birds after the flashy bird models are shared at the front of the class, the importance of "choosiness" among less flashy sexes and the concepts of inter-sexual selection and fitness become clearer. While we only graded the activity handouts for participation and completeness, students' responses on the handout suggested that most students understood concepts of sexual selection and fitness. Additionally, as a more concrete example of whether our learning objectives were met, 134 of 138 students who took the third exam in our class (which included the mechanisms of evolution unit) correctly answered a multiple-choice question about sexual selection in male peacocks regarding disadvantages of tail feather length. Similarly, 113 of 138 students correctly answered a multiple-choice question about the definition of an organism's fitness. Thus, the majority of students also seemed to understand the concepts of sexual selection and fitness on this more summative assessment, though we cannot say for certain that participating in the sexual selection activity resulted in higher scores on these exam items (though it would be great if they did!).

While here we do not share the specific assessment items we have used, as they are copyrighted by the textbook company we chose to use in Spring 2019, we do provide sample exam questions regarding sexual selection in S4. Modeling Exercise in Sexual Selection - Sample Exam Questions. We have developed sample scoring rubrics for instructors who want to more summatively assess their students' lesson outcomes (S5. Modeling Exercise in Sexual Selection - Sample Bird Model/ Trait List Rubric).

Student Reactions to the Activity

Students referred to this lesson throughout the semester, positively reminiscing about how this was one of the few—if not the only—college course(s) in which they were able to be creative and use craft materials to develop models. Our students had fun sharing their models at the end of the class period, interspersing some bits of humor into their explanations of their traits as they attempted to "woo" their less flashy counterparts listening to their presentations. We think the fact that this activity is centered around sexual selection in birds rather than mammals or humans makes students more comfortable discussing the topic of sex, and further allows them to enjoy all aspects of the activity. Students continued to mention to me at the end of the semester that they wished we could have engaged in more activities like the avian sexual selection modeling.

Improvements for Future Iterations of the Activity

The primary issue we experienced while implementing this activity was time management, which may have been exacerbated by our large class size (~150 students); as the instructor, you have to be aware of when to move on to the next portion of the activity, and also provide students constant updates regarding how much time is remaining for each portion of the activity (this is where the provided activity timeline comes in handy!). While this activity is certainly doable in a 50-minute lecture period, a slightly longer class period would be beneficial for such parts of the activity as gathering craft materials for the bird models. We learned to never underestimate how long students can take to decide on the colors and types of modeling dough and craft materials they will use to create their flashy bird models! A real value of this being a group activity is that individual students may become actively involved, rather than fall back on common excuses to justify their limited engagement (e.g., I'm not creative, I can't draw, I'm not an artist).

The roles of the two groups are certainly different. If the less flashy groups generate their lists of preferred traits faster than the flashy groups who are developing models, you could require less flashy groups to share and discuss their lists with other less flashy groups and revise their lists of preferred traits accordingly. Further, if you want to ensure that students do not feel rushed when completing the handout questions, but you do not want to assign these items as homework, you could set aside time for students to complete these assessment items in their groups during the following class period.

Unrelated to timing, this activity could easily be adapted for other animal groups like mammals, reptiles, etc., depending on the learning goals and curriculum of your class, though we chose to focus on a fictitious avian species since birds provide such great examples of inter-sexual selection. If your students are interested in learning more about sexual selection in humans, you can direct them to such resources as Miller's (21) review on how mate choice shapes human nature. Contingent upon the energy, comfort levels, and maturity of students in your class, you could also require flashy bird groups to act out any behaviors (e.g., goofy courtship dances, songs, etc.) they think their flashy bird would engage in to woo their less flashy mates, as is required in Case's and McNutt's lesson plan on sexual selection geared toward high schoolers (available on CPALMS). It really is up to you regarding what you want your students to take away from this learner-centered sexual selection activity, so feel free to use it simply as a jumping off point if you would like to take it in a different direction!

SUPPORTING MATERIALS

- S1. Modeling Exercise in Sexual Selection - Lesson Timeline
- S2. Modeling Exercise in Sexual Selection - Powerpoint Slides
- S3. Modeling Exercise in Sexual Selection - Handout & Answer Key
- S4. Modeling Exercise in Sexual Selection - Sample Exam Questions
- S5. Modeling Exercise in Sexual Selection - Sample Bird Model/Trait List Rubric

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