| **Title:** | Sex Role Reversal in Guardian Frogs: |
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| **SubTitle:** | Why exceptions matter in biology and everyday life |
| **shortTitle:** | guardianFrogs |
| **Module:** | NA |

[**Client Goals Worksheet**](https://drive.google.com/file/d/14OjmIVuIx0KR1s9dlZf6uem2Q09Rr9Ns/view?usp=sharing)

**Sponsored By** (blurb ~30 words):

| Johana Goyes, PhD |
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| **Est. Time:** | 3 x 45 min |
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| **For Grades:** | 5-8 |
| **Target Subject:** | Science |
| **Lesson Hook:** | Are guardian frogs exceptions to the rule? |
| **Driving Questions:** | * Are guardian frogs an exception to our understanding of typical sex roles? * How do we use scientific methods to measure and interpret biological variation? |
| **Broader Qs & Themes:** | * What types of behaviors are used in sexual selection? * How do these behaviors typically differ between the sexes, and what is sex role reversal? * How can we use scientific methods to test the hypothesis that guardian frogs display sex role reversal? * Why do exceptions matter? |
| **Learning Targets:** | Students will be able to:   1. Explain how animal behavior facilitates in reproduction 2. Understand the concepts of sexual selection and sex role reversal; understand the factors that contribute to sex role reversal 3. Understand that biological data are variable; Use statistical language (*e.g.* mean, range) and data visualization to describe variation in biological data; Learn to test hypotheses by interpreting data that shows variability, using scatter plots and box plots of real biological data 4. Cite textual evidence from a scientific text to support analysis of what the text says explicitly as well as inferences drawn from the text. 5. Understand that there there are exceptions in biology by integrating evidence from scientific text and graphs of real biological data [and understand why it is important to study these exceptions in biology and other disciplines] 6. Extra: Understand the relationship between biodiversity and geography, with focus on the geography of Borneo |
| **Tags (up to 10):** | animal behavior, sexual signaling, frogs, sex role, sexual selection, biological exceptions |

Standards Alignment

| **Learning Goal** | **Standards Alignments** |
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| 1. Gain the knowledge to explain how animal communication facilitates in reproduction | **NGSS Science:**  INFO-M1: Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).  **CC ELA:**  RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue. |
| 1. Understand the concepts of sexual selection and sex role reversal; understand the factors that contribute to sex role reversal | **NGSS Science:**  LS1.B-M1: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.  LS1.B-M2: Animals engage in characteristic behaviors that increase the odds of reproduction.  **CC ELA:**  RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. |
| 1. Understand that biological data are variable; Use statistical language (*e.g.* mean, range) and data visualization to describe variation in biological data; Learn to test hypotheses by interpreting data that shows variability, using scatter plots and box plots of real biological data | **NGSS Science:**  DATA-M4: Analyze and interpret data to provide evidence for phenomena.  DATA-M5: Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.  AQDP-M1: Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.  AQDP-M5: Ask questions that require sufficient and appropriate empirical evidence to answer.  PAT-M4: Graphs, charts, and images can be used to identify patterns in data.  PAT-E3: Patterns can be used as evidence to support an explanation.  AQDP-M1: Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.  **CC ELA:**  RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).  **Math:**  6.SP.B.4: Display numerical data in plots on a number line, including dot plots, histograms, and box plots. |
| 1. Cite textual evidence from a scientific text to support analysis of what the text says explicitly as well as inferences drawn from the text. | **CC ELA:**  Write opinion pieces on topics or texts, supporting a point of view with reasons and information.  WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research.  RH.6-8.2: Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct from prior knowledge or opinions. |
| 1. Understand that there there are exceptions in biology by integrating evidence from scientific text and graphs of real biological data [and understand why it is important to study these exceptions in biology and other disciplines] | **NGSS Science:**  CEDS-M4: Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.  AQDP-M7: Ask questions that challenge the premise(s) of an argument or the interpretation of a data set.  **CC ELA:**  RH.6-8.2: Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct from prior knowledge or opinions.  WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research. |
| 1. Understand the relationship between biodiversity and geography, with focus on the geography and culture in Borneo | **C3 Social Science:**  D2.Geo.5.6-8: Analyze the combinations of cultural and environmental characteristics that make places both similar to and different from other places.  D2.Geo.9.6-8: Evaluate the influences of long-term human-induced environmental change on spatial patterns of conflict and cooperation. |

Generic standards alignment notes:

| Target Standard (NGSS): *Disciplinary Core Idea (DCI)*   * **LS1.B-M2** Animals engage in characteristic behaviors that increase the odds of reproduction. |
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| Connected Standards:NGSS *Science and Engineering Practices (SEP)*   * **AQDP-M1:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. * **AQDP-M5:** Ask questions that require sufficient and appropriate empirical evidence to answer. * **AQDP-M7:** Ask questions that challenge the premise(s) of an argument or the interpretation of a data set. * **CEDS-M4** Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. * **DATA-M4:** Analyze and interpret data to provide evidence for phenomena. * **DATA-M5:** Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. * **INFO-M1:** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). * **LS1.B-M1:** Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. * **LS1.B-M2:** Animals engage in characteristic behaviors that increase the odds of reproduction. * **PAT-E3:** Patterns can be used as evidence to support an explanation. * **PAT-M4** Graphs, charts, and images can be used to identify patterns in data.   *Cross-Cutting Concepts (CCC)*   * **PAT-M4** Graphs, charts, and images can be used to identify patterns in data.  Common Core ELA  * **CCRA.L.4:** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. * **RI.6.7:** Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue. * **RH.6-8.2:** Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct from prior knowledge or opinions. * **RH.6-8.2:** Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct from prior knowledge or opinions. * **RST.6-8.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. * **RST.6-8.7:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). * **WHST.6-8.9:** Draw evidence from informational texts to support analysis, reflection, and research.  Common Core Math  * **6.SP.B.4:** Display numerical data in plots on a number line, including dot plots, histograms, and box plots.  C3 Social Studies  * **D2.Geo.5.6-8:** Analyze the combinations of cultural and environmental characteristics that make places both similar to and different from other places. * **D2.Geo.9.6-8:** Evaluate the influences of long-term human-induced environmental change on spatial patterns of conflict and cooperation. |
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**Lesson <-> Research Connections (200–350 words)**

| ### Lesson Connections to this Research |
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**Loose Narrative** (Just the gist; full procedure will go in meta/procedure.xlsx)

| **Day 1** will introduce students to sexual selection and the guardian frog system. Students will learn about typical sex roles and that while many species generally follow these patterns, there can be variation in behavior. Students will then learn about sex role reversal, an extreme case. Students will walk through a few hallmark examples of sex role reversal. Next, students will learn about guardian frogs and Johana’s work in Borneo. The lesson will end on a cliffhanger—female guardian frogs seem to exhibit male-typical behaviors, but is this species a truly sex-role-reversed species? How can we tell?  **Day 2** will continue the narrative by introducing students to hypotheses and predictions, and ways that scientists can test these things. The students will form predictions for the hypothesis that guardian frogs are a sex-role-reversed species, then examine real biological data to test their predictions and hypothesis. They will first learn basic statistical language to describe data (mean, range). Then, they will examine data on female vocalizations by assessing it statistically and visualizing it in a boxplot. |
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**Abstract (<250 words)**

| (151 words so far)  In sexually reproducing animals, males and females typically behave differently—in predictable ways that help ensure their survival and reproduction. These differences in behavior are called “sex roles,” and while this term can be applied to humans, usage in this lesson is restricted to nonhuman animals (mostly frogs). In a majority of species, males compete intensely for mates and provide little parental care, while females carefully select a mate and provide the bulk of parental care. However, it is often said that “The only rule in biology is that there’s an exception to every rule.” This is the case with sex roles, and in some extreme cases (e.g. seahorses), species exhibit complete sex role reversal—males engage exclusively in “female-typical” behaviors (like protecting and nurturing offspring), while females engage only in “male-typical” behaviors (competing for mates and contributing little parental care).  In this 3-day lesson, students will be introduced to guardian frogs, a small amphibian from Borneo–a large island in southeast Asia. Females of this species engage in many “male-typical” behaviors, and males engage in many “female-typical” behaviors. Students will examine real biological data to test the hypothesis that guardian frogs are a sex-role reversed species, using statistics and graphical analyses to evaluate and interpret biological patterns and address research questions. |
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**Scientific Background (200–350 words)**

| ### Scientific Background  Further Reading: Add links with markdown format: [*link text*](*link URL*)  - |
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**Previous notes from consultation with Johana:**

| **Matt:**   * I like the idea of framing this around "there are exceptions to every rule"   + Elaine: We'll need some other examples of "exceptions" in science but also in other disciplines. * Do we make a science-targeted lesson out of it? * What if we had them analyze some calls to answer a question, don't mention the sex * Do some storytelling, building up the setting in Borneo   + She's got some really [good media for this ready to go](https://jogoyesvallejos.weebly.com/sci-comm.html) * Maybe play some soundscapes to really set the scene. * Have them do some data aggregation or something   + Maybe IDing frog calls using some resource (spp. ID) * Then bombshell halfway--these are female frogs. * Why do these females call? Why do they not normally?   + Sex role reversal/male parental care * Some stats about number of frog species and how many do/don't call. * Spend time w/ denouement, reflection   + Is there a general lesson about exceptions to every rule?   + Explain conservation status   **Elaine:**   * Definitely a science focused lesson, I'm thinking earth science and some bio. We can blend with english (reading/writing), maybe some math, and geography (of Borneo and where it is relative to US, unique features of Borneo, ?) * Topics: * 1. Guardian frog - looks, location, male frog call, why different from other frogs (males stay with eggs, Borneo vs. South American frogs, etc.). * 2. Sex Role Reversal - defining it, how it's exhibited in nature, why this is significant.   + - Activity: observe some animals (maybe pre-recorded on youtube or something) and determine what the sex roles are: "standard" (?) or Reversal (I don't know what not reversed sex role is called). * 3. Frog call calls (male then female)   + - * Why do frogs make calls?       * comparing male/female frog calls       * Maybe create visualization of data (graph?) - I don't want to copy too much from the other lesson, but this is also a standard practice in research. * 4. "rules" of nature and how there are exceptions (and why exceptions exist)   + - * Biology is sometimes referred to as “the **science** of **exceptions**.”       * Outliers.       * Maybe how outliers are identified in data/graphs       * What finding an outlier could mean for science discovery       * What other rules of nature do we know - and what's an exception to that rule? This could be an activity. Maybe like "what goes up must come down. Except when... (students finish this statement with) there's no gravity" or something like that. * 5. what these findings mean for science / rules of nature, etc. * Johanna's website includes some lesson ideas she's done with students in the past. I wonder if we could incorporate her "methods for observing animal behavior" as an integrated "experiential learning" activity? Ask students to observe some animals in their own community, develop research questions with help from the teacher, and create a science poster (which can be created virtually or hardcopy). This actually could be a good activity for schools that still do science fairs (do schools still have those?) and students can use their behavior observations and poster in the science fair. |
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# Other info

Field site coords: 4.550000, 115.150000 / 4°33'00.0"N 115°09'00.0"E

# New Outline

## Itinerary:

#### Day 1: Defining a Pattern in Nature:

Engagement Hook + Knowledge Scaffolding: Have students derive general rule that “males tend to compete and advertise more; females tend to be choosy”. Should highlight a couple exceptions (Jacanas and pipefish). Sometimes there are exceptions to rules. Tease frogs with video from Johana.

#### Day 2

Introduce Borneo and the system and begin data analysis. Set up hypothesis testing for sex role reversal. Introduce data, which they’ll finish analyzing for homework. Include reflection about

#### Day 3

Quick review and opportunity for discussion (10min) to close out. Option for extensions.

Future Extensions

Probably continue another stage of analysis and conclusion. Analyze data on Bornean biodiversity loss (maybe this is a very small thing). Discuss and reflect on why exceptions matter and what the loss of such exceptions means for humanity.

Research on what’s causing most of the deforestation in Borneo and what individuals can do about it.

## Detailed Outline

#### Part I: Deriving the Rule (and discovering the exception): “Role with It” simulated data collection

Categorize the following. Among nonhuman animals, what sex is:

* showy
* competitive
* loud
* nurturing
* protective

What are conventional sex roles in animals?

* Goal of scientists is to define a pattern by looking at lots and lots of species.
* Try to categorize, generally speaking, what the “sex roles” are for each sex across animals.
* How do males and females generally behave when it comes to mate attraction, competition, and contributions to offspring?
* (Side note: babies are only for humans. A better term for the results of reproduction in nonhumans is “offspring”)

Side note:

* Not talking about humans
* Sex refers to male and female, usually determined by sex chromosomes in animals
* Gender is concept that applies to how humans identify with a particular group (male, female, or nonbinary). Whether animals have gender or not is hard to test, since they cannot tell us how they perceive themselves.

30min Student activity: “Role with It” (Interactive data collection)

* Students are distributed 20 cards (m & f for 10 species); some students may get more than 1 (you can give more than 1 student the same card if you have a big class)
* All but 2 (jacana and pipefish) have M only or M & F mate attraction/competition (conventional sex roles); But wrens have both, and we have the 2 sex role reversed species. What do these 3 all have in common that is unusual/missing in the others? Male parental investment.
* Activity “Role With It”:
  + Presentation goes through each species and sex in random order
  + If you have that card you look at the value and signal accordingly. Each has a visual & an acoustic signal value. Visual signals go from 1-3; acoustic: 0-3.
    - Acoustic Signaler: Say your name 3 times (at an audible, but respectful volume according to the level)
    - Visual Signaler: Do a little dance according to your level; (Gif of fortnight celebration or Steve Zissou doing very subtle dance) to accommodate introverts
    - Does not signal: Quietly raise your hand
    - Teacher will call on you: You read your script: “Male bullfrogs croak to attract females. They do not care for offspring, they only pass on their genes.”
    - Presentation prompts them to fill in answers on the worksheet
    - BEFORE activity begins, opportunity to trade cards (to be more or less boisterous)

TAKEHOME: We want students to get invested in the storyline (have fun). Collect data. Use the data to recognize that 1) there is variation in who is choosy/flamboyant and how much parental investment there is; 2) males tend to be more flamboyant, with females contributing more to offspring (conventional sex roles); 3) in cases of sex role reversal, males contribute more to offspring.

**Part II: Welcome to Borneo: (You’re testing whether this is the first sex-role reversed frog species)**

1. **Start class with playing soundscapes from Borneo**

## Media

* [Frog soundscapes](https://soundcloud.com/frogvoicesofborneo/sungai-belalong-megophrys-nasuta-soundscape)
* [Guardian Frog calling behavior](https://youtu.be/LAqSHDdTKMw)
* [Johana’s presentation](https://youtu.be/eX5abcrmE7g)
* [Johana’s website](https://jogoyesvallejos.weebly.com/sci-comm.html)
* [Frogging at Kuala Belalong](https://www.youtube.com/watch?v=TOwQ8xQH9O4&t=1s)