Exploring Bird Evolution: An Ornithology Lesson for Middle and High School Students

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Exploring Bird Evolution: An Ornithology Lesson for Middle and High School Students

An honors thesis presented to the
Department of Atmospheric and Environmental Sciences,
University at Albany, State University of New York
in partial fulfillment of the requirements
for graduation from The Honors College.

Amanda Marie Colley
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Academic Advisor: Justin Minder, Ph.D

May, 2016
Abstract

Hands-on learning is believed to be one of the best ways to engage students in science. Science is meant to invoke curiosity and imagination. It is up to educators to teach science in a way that will welcome students rather than scare them away. In this project, a science lab activity was designed, in collaboration with the New York State Museum, to help students better understand the concept of evolution as it appears in birds. Students must measure the leg and wing bones of six different bird species, and find the ratio between each bird’s leg and wing length. Students are then asked to compare these ratios between the birds and each of their feeding niches. This lesson was designed to help students better understand the theory of convergent evolution. Once the lesson was designed, it was tested on a group of 60 science teachers. The teachers helped give the museum educators a better idea of how it would work in a classroom setting. The lesson was revised to better fit the needs of the teachers and to help bridge the gap between the museum and the classroom. Some revisions that were made were to include more background information, decrease the number of bird species, and include more detailed diagrams. Another idea to make this lesson more accessible to teachers was 3D printing. The idea is that the museum could scan the bird bones and have the files available online for educators to 3D print the bird bones for their school. This paper discusses a hands-on science activity created to help bring museum resources into the classroom and give students an opportunity to learn scientific concepts.
Acknowledgments

I would first like to thank Dr. Jeremy Kirchman for his unending support in this project. Without his guidance and insight completing this thesis may have proven to be an impossible task. I would also like to thank Dr. Justin Minder for his guidance throughout my college career and for being a reviewer of this project. Thanks must also being given to Hatti Langsford for her help in testing this project. I would like to extend my thanks to undergraduate student Iris Brody and the Makerspace office for all of their help.

Lastly, special thanks must also be extended to all of my friends and family for all of their love, guidance, and support. They have pushed me to pursue my dreams and to never back down from a challenge. They helped make this project possible, and I offer all of my gratitude to every person who has helped me in this journey.
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**Introduction**

In science education, teachers are always looking for new ways to teach concepts in a way that will be understood and remembered by students. Science can be a difficult topic to teach, and it must be taught in a way that will encourage students to seek more. There have been studies performed that support the theory that hands-on learning is extremely beneficial in science education. Hands-on activities are shown to improve cognition and attitude towards science better than textbook based learning (Sadi et al, 2011). This leads to students performing much better in the classroom. Due to this, a core part of any science program presently are laboratories that demonstrate scientific concepts.

Another study was performed on middle school students to see the effect of hands-on science activities in the classroom for the school year. In the study, the results were broken down by gender. Females at the beginning of the year showed a lower perception of science as a career than males. At the end of the year and after all the activities, there was no significant difference in the perception of science as a career between females and males (Christensen et al, 2013). From this study, it can be inferred that hands-on science activities help to close the gender gap in students’ perception of STEM education. This shows the importance of the three Hs in education, hands-on, heads-on, and hearts-on. The three Hs put an emphasis on the child’s experiences while learning. If students have a bad experience while learning, it may dissuade them from continuing to learn. Another study was done on the attitudes of undergraduate students on the theory of evolution. In the study, it was found the student’s attitudes toward the theory were very low, and that constructivism may help (Apaydin et al, 2009). Constructivism is the theory that people learn by constructing their own knowledge and understanding through experiences and reflecting on those experiences. The study also suggested that more research on the education of the theory of evolution needs to take place in order to help teach it in a better way.

One fundamental concept that science educators are expected to teach is the theory of evolution. Teachers have a hard time teaching evolution concepts due to students already having their own perceptions of evolution. Many teachers are unsure of how to teach evolution. They worry about students with preconceived notions, sensitive topics when it comes to religion, and have reported a general lack of knowledge on the concept (Töman et al, 2014). There have been studies on what students think about learning evolution, and how that affects pre-service
teachers. In a particular study, it was found that a majority of students had negative views about evolution from the idea that humans all come from one common ancestor (Töman et al, 2014). The same study noted that pre-service teachers are against teaching the subject due to society’s prejudice against it. It was concluded that better training was needed to help teachers educate students about evolution. There are several aspects of scientific education training that pre-service teachers need. Many don’t have a background in science, and without the basic understanding of science it can prove impossible for the educator to teach. Many also do not know how to deal with the issue of controversy in evolution education. Teachers must be trained in order to tackle this sort of problem in the classroom.

In this project, a lesson plan was created to be used by science teachers. The lesson plan is designed to be a hands-on project to help students learn the theory of convergent evolution. In this activity, students will observe examples of convergent evolution in birds. It was designed for students to gather research, make measurements, discuss observations, and make predictions based on their data. The lesson was created in collaboration with the New York State Museum for science teachers to use in their class or to bring their students to the museum to learn.

**Museum Education**

Education is an integral part of any museum. Museums are not just places to hold artifacts, but great learning centers as well. These learning centers have the unique opportunity to create interpretive displays that draw people in and help people comprehend subject matter through visuals and physical objects. Museums are also able to help supplement the curriculum in a traditional classroom. It is important for educators to use the resources they have available to them, and museums are a huge resource. Pre-service teachers that communicate with museum educators will have more opportunities to fulfill curriculum requirements, opportunities to help out at the museum, and find other educational opportunities (Kaschak, 2014). By bringing students to museums, they can make connections between science, history, and society. During a museum visit, students have the opportunity to discover and choose what interests them, which promotes better learning (Kaschak, 2014). Some museums allow students to make connections by allowing them to observe and examine artifacts. The New York State Museum offers a wide variety of programs for visiting groups. Each program was created to help meet New York education standards and offers programs for pre-k through 12th grade aged students. The
museum also features a hall of birds that displays the diversity of birds in the state. The ornithology collection features 12,000 bird skins, 5,000 bird skeletons, and 6,000 sets of eggs. The collection offers an opportunity for learning from primary sources.

The purpose of this paper is to describe how a lesson plan on evolution was created and to explain the usefulness of the lesson plan.

Creating the Lesson

The lesson plan, which can be found under Appendix I in this paper, was created to help students understand convergent evolution. This lab is meant to be completed in two class days of about 45 minutes each. The age range that it was created for is middle through high school students. The main goal of the lab is to have students study bird bones, a primary source, to discover the different and similar adaptations of each bird species. The lesson was created with New York State science curriculum standards in mind (C&I, 2013). It promotes specific NYS science standards, including: scientific inquiry, use of tools for measurement, peer discussion, teaches the theory of evolution, and helps describe structure and function relationship within bird species. The lab also has students utilize tables and graphs, and present their information to the rest of the class.

The first objective is to identify the correct bones. The bones that the students have to look for are the four longest leg bones and the four longest wing bones (Appendix I, page 20). The idea is that students will work in groups of 3 to 4 to measure each bird’s leg bones and wing bones to find overall leg and wing length. Students will then observe from these measurements whether the legs or the wings are longer in each specific bird species. Next, as a class, the students must use their graphing skills (Appendix I, page 15). They must plot leg length against wing length, and see where each species falls relative to the trend line. Once all of the data is entered in the graph, students will move on to the discussion portion on the lesson. During the discussion, students are asked to answer several questions as a group that are meant to guide them. These guiding questions (Appendix I, page 22) connect the bird’s leg length versus wing length to its feeding niche. Generally, when a bird has longer wings than legs, its feeding niche is aerial, meaning that they use flight to catch their prey. Birds with shorter wings than legs are generally ground foragers. Students can either work together as a class or as individual groups to
answer the discussion questions. The questions are designed to invoke a discussion about bird adaptations, feeding niches, and convergence. Schools are able to borrow sets of bones from the museum by contacting the curator of birds and having them sent to the school.

**Testing & Revising the Lesson**

The lab was put to the test at the 2015 New York State Museum Teachers’ Evolution Workshop. The workshop is led by Curator of Birds Dr. Jeremy Kirchman and is meant to arm middle and high school science teachers with the tools and ideas they need to teach about evolution. At the end of the workshop, the teachers got to run through the lab and provide their feedback. A group of about 60 middle school science teachers performed the lab. Museum educator Hatti Langsford helped to organize the test run, and came up with the idea of assigning group roles. Each person in a group would be assigned a specific role, such as researcher, to perform. I also helped to run the lab and answer any questions the teachers had. At the end of the trial run, the teachers were mostly pleased with the lab, and provided excellent feedback. The feedback was collected via a survey sheet that was given to them at the end of the workshop and included a couple of questions about what they thought of the lab.

One of the main issues that was brought up was the difficulty in identifying the correct bones. This was also something we noticed during the test run since many teachers called us over to help identify. Some solutions that were suggested included better diagrams of the bones, narrowing down the choices of birds, and high quality photos of the bones. To remedy this, we included better diagrams as well as high quality photos. Teachers are also able to narrow down bone choices if necessary. Another issue the teachers found was that there were too many bird species. There were originally eight species, but it was narrowed down to six species. The third suggestion was to provide more information about the birds. The teachers believed that students would need to be provided background information in order to better answer the discussion questions. A pre-lab section was added (Appendix I, page 16) with the goal of having the students research each bird species. In this research, students will learn the scientific name of each bird, its family, and what behavioral category it occupies when feeding. Bird information cards were also created to help target the research and make it easier for younger students (Appendix II). Teachers can either decide to have students use the bird information cards for the pre-lab, or they can have students conduct research on the internet. Although this lesson is
recommended for both middle and high school students, more pre-teaching may be necessary for younger students.

3D Printing Bird Bones

In order to make the lab more accessible to teachers, the lab can be uploaded to the New York State Museum’s website for teachers to download. Another way to make the lab more accessible, especially for those that may not be able to borrow the bird bones, is to use a 3D printer to make models of the bones. There are a few ideas behind this. The museum itself could print sets of bones to loan along with the real sets of bones, and the scanned files of the bird bones could be shared online for educators to use and print their own sets of bird bones. We brought up this idea at the workshop and the feedback was overwhelmingly positive. A majority of the teachers claimed to be interested in printing the bird bones themselves. In order to do this, the bones must first be scanned.

After several test scans, a high quality scan was used to best capture a bird humerus. While scanning, we learned that it was much better to take a higher quality scan, even though it takes longer than a lower quality scan. The scanner takes multiple scans of the bone from different sections and the computer must try to piece these scans together to create one image. With a higher quality scan, the computer is better able to piece the whole bone together. We scanned the bone in high definition which took about 27 to assemble. Once we believed we had a good enough scan, it was brought to the University at Albany’s Makerspace office. Makerspace is a program in the Informatics Department that utilizes 3D printers for student projects. The printer being used in this program is a Makerfront 3D printer, (figure 5). The company sells the parts for the printer and it was the students’ in this programs task to put the printer together. The printer uses an i3PRO extruder, which is essentially the part of the printer that heats up the filament and pours it out to build something. The filament used at the Makerspace office is all recycled material and we chose a white colored filament.

Undergraduate student Iris Brody took on the task of printing the bone. The first attempt, pictured in figures 4 and 5, printed the bone horizontally with some supports. This method left many gaps, so the print had to be canceled partway through. It was decided that the bone needed to be printed vertically with supports all over. The supports are printed to help keep the structure
in place while it is printed, and can be removed afterward. The resulting bone model was similar to the original, although there were still many gaps in the bone (refer to figure 6). Since the bone is translucent, we believe that the scan missed many parts of the bone by shooting through it. A higher quality scan may be able to stop the bone from printing with gaps. It may be necessary to scan the bone with a higher quality scanner. Until a better scan is obtained, the rest of the bird bones cannot be scanned or printed.

Figure 4. First attempt at printing the humerus.  
Figure 5. The Makerfront 3D printer.
Summary and Conclusions

This lesson plan was created with the purpose of providing educators with a new way to teach the theory of evolution. The lab was created with middle and high school New York State science standards in mind. The teachers’ workshop was utilized to test the viability of the lesson plan. Feedback obtained from the workshop was used to improve the lesson plan. The lab discussed in this paper uses the ideas of constructivism, and has the opportunity to teach evolution in an engaging way. It can be concluded that museums have the ability to provide extra learning opportunities. Museums can help develop new ways of teaching that educators can utilize. Educators must work closely with museums in order to benefit from them. The lesson plan has the potential to successfully teach students the theory of convergent evolution. In the future, if the bird bones could be scanned at a higher quality, it would be possible to share the scans online for teachers across the country to use. This would be a huge step in sharing museum collections with educators, and could open the door for many more education projects. It is important that we explore all of our options in education, to make sure that students are learning in a positive way.
References


Appendix I

Teachers’ Guide: Exploring Bird Evolution

Bird bodies are adapted to different feeding niches

Introduction:
In this hands-on lab, students will learn more about bird adaptations, especially those related to locomotion and different feeding behaviors. This activity is designed to help students better understand how scientists use specimens to study evolution, and to further explore the topics of natural selection, morphological adaptation, and convergent evolution.

Background:
Skeletons preserved as museum specimens are used to study the evolution of bird species. When skeletons from different kinds of birds are compared, researchers can see how their bodies are adapted to different feeding niches. For example, many different kinds of birds (swifts, swallows, nighthawks, and kites) have evolved long wings and short legs as they adapted to capture and feed on flying insects. This process, where multiple distantly related species independently develop similar traits, is called convergent evolution. The classic convergent evolution example is the evolution of powered flight. This trait can be found in insects, bats, pterosaurs (now extinct), and birds; it evolved independently in these four lineages.

In this activity, we will ask students to interpret the results of their skeleton comparisons within the framework of convergent evolution and adaptation to different feeding niches.

Materials:
- Calipers or rulers with millimeter graduations
- 6 sets of bird leg and wing bones from NYSM skeleton specimens
- Student handout (Data sheet/Instructions/Questions)
- 1 set of bird species info sheets per group

Thoughts:
Depending on the length of class periods, the teacher may want to split this activity up over two days. Students could collect measurements and research the bird species on day 1, and on day 2 the class would pool the data, set up the graph and answer the discussion questions.

Teachers may want to ask their advanced students to make their own graphs (either printed from Excel or on graph paper). Alternatively the teacher can make the graph using the instructions in this Guide and project it in the classroom to enable the students to answer the discussion questions. For skeletons that were measured by multiple groups, plot them all to see how well they cluster, indicating repeatability of the measurements.

Additional discussion or follow-up activities can focus on patterns of divergence between closely related species (the two hawks, the two passerines), and the convergent morphology birds with similar feeding niches (the swallow and the nighthawk are aerial insectivores; the grouse and the roadrunner forage on the ground). Presenting and discussing a phylogenetic tree will help students see how distantly related birds have “converged” upon similar traits. This background information may help students better understand the concept of convergent evolution.
Additional Resources:

- To search for additional information on the bird species in this activity:  
  https://www.allaboutbirds.org/

- For a good lesson in bird anatomy, including your chance to “Build a Bird” try:  
  https://academy.allaboutbirds.org/features/birdanatomy/

- For information on convergent evolution:  
  http://evolution.berkeley.edu/evolibrary/resourcelibrary.php
Instructions for Building the Graph in Excel
(For Microsoft Office 2013)

1. Enter all information into excel, with the specimen number in column A, species name in column B, leg length in column C, and wing length in column D. (Make sure to label column A and B).

2. Next, highlight all data in column C and D, then click the insert tab. In the charts section, select “Insert Scatter (X, Y)”.

3. Click on the “+” button at the upper right of the graph and add axes titles and a chart title.

4. To add data point labels, click the “+” again, and click the data labels option. Excel will automatically label the point by its leg length. Go through your data and appropriately label each data point with its species name.

5. Next, to add a trend line, click on the “+” button and on the trend line option, click the arrow. From there, click on “more options”.

6. Make sure the trend line is linear, and then set the intercept at (0,0).
Pre-Lab Bird Research
Discover the feeding niches of birds

**Background:** Just as bird beaks are very different from one another depending on what kind of food a bird eats, the wings and legs of different bird species can also be very different from one another. The wings and legs of birds are a reflection of each bird’s “feeding niche”, its method for searching for and catching its food. Some birds may have long, pointed wings and short legs, because they are adapted for catching insects during flight, while other birds are adapted for foraging on the ground with long legs and short wings (such as chickens). In this lab, you will test to see if data from bird skeletons supports this theory. First, you must learn more about the species you are testing.

**Research:** First, go to the website allaboutbirds.org, or refer to the bird information cards provided. Next, using the table below search each species name in the search box. When you search the species name, you should find the common name and the behavior of the species. The behavior can be found under the Life History tab. After reading about the behavior of the bird, predict whether the legs will be longer or shorter than the wings for each species.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Family</th>
<th>Behavioral Category</th>
<th>Prediction (legs shorter or longer?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Nighthawk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruffed Grouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caspian Tern</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Greater Roadrunner</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Cooper’s Hawk</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Broad-Winged Hawk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Research Questions:

1. Identify and describe two main feeding niches in the bird species you learned about.

2. Compare the diet and feeding niches of the hawk species, Broad-winged Hawk and Cooper’s Hawk.

3. Explain the predictions you made in the table about and what led you to making those predictions.
Exploring Bird Skeleton Evolution
Bird bodies are adapted to different feeding niches

**Background:** In this portion of the lab we are going to examine the ways that bird morphology (body shape) is adapted to different feeding niches. We will measure wing and leg bones from species with very different foraging behaviors. We will interpret the results in the context of convergent evolution, which is the process where multiple species independently evolve similar traits although they are not closely related on the phylogenetic tree.

**Procedure:**

1. In groups of 3-4 students, select your first bird to measure. Write the species name and common name on the data sheet.

2. Using Figures 1 and 2, identify the femur, tibiotarsus, tarsometatarsus, and the longest toe bone.

3. Measure the length of each of these four leg bones (in millimeters) and enter the data on your sheet. Add the measurements together to get the total length of the leg.

4. Next, find the humerus, ulna, carpometacarpus, and phalanx 1 of the second digit.

5. Measure each wing bone just as you did in step 3, add each measurement together, and enter all data into the data sheet.

6. Trade places with another group and measure a different bird repeating all previous steps.

7. Each group should measure three skeletons. Some skeletons will be measured more than once. After your group has measured three bird specimens, enter your information in the class data sheet.

8. Using the pooled class data, create a graph in Excel with total leg bone length on the y-axis, and total wing bone length on the x-axis.

9. After all data points have been plotted, draw a line of best fit that passes through the origin of the plot (0, 0). Bird species that fall well above the line have relatively long wings, and birds that fall well below this line have relatively long legs.
Adaptations to flight

Fusion of vertebrae together and to pelvis gives rigidity to skeleton during flight.

Deep 'keel' to sternum allows attachment of pectoralis major and supracoracoideus.

Figure 1. Skeleton and wing of a pigeon.
Figure 2. Two views of the wing bones (upper in each photo) and leg bones (lower) of a grouse.
### Data Sheet

**Student Names:**

---

#### Skeleton 1.

**Species Name:** ____________  **Common Name:** _________________________

Enter the length of each leg bone (in mm) in the table below and calculate the total length.

<table>
<thead>
<tr>
<th></th>
<th>Femur</th>
<th>Tibiotarsus</th>
<th>Tarsometatarsus</th>
<th>Longest toe (pedal phalanx)</th>
<th>Leg total length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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</table>

Enter the length of each wing bone (in mm) in the table below and calculate the total length.

<table>
<thead>
<tr>
<th></th>
<th>Humerus</th>
<th>Ulna</th>
<th>Carpometacarpus</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Digit phalanx</th>
<th>Leg total length</th>
</tr>
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#### Skeleton 2.

**Species Name:** ____________  **Common Name:** _________________________

<table>
<thead>
<tr>
<th></th>
<th>Femur</th>
<th>Tibiotarsus</th>
<th>Tarsometatarsus</th>
<th>Longest toe (pedal phalanx)</th>
<th>Leg total length</th>
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<table>
<thead>
<tr>
<th></th>
<th>Humerus</th>
<th>Ulna</th>
<th>Carpometacarpus</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Digit phalanx</th>
<th>Leg total length</th>
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#### Skeleton 3.

**Species Name:** ____________  **Common Name:** _________________________

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<tr>
<th></th>
<th>Femur</th>
<th>Tibiotarsus</th>
<th>Tarsometatarsus</th>
<th>Longest toe (pedal phalanx)</th>
<th>Leg total length</th>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Humerus</th>
<th>Ulna</th>
<th>Carpometacarpus</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Digit phalanx</th>
<th>Leg total length</th>
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</tbody>
</table>
Discussion Questions:

1. Which bird species is found furthest above the line in your class graph? Describe the feeding behavior of this species.

2. Why are *Bonasa umbellus* and *Geococcyx californianus* found below the line?

3. Notice the difference in the relative length of their wings between the two hawks, *Accipiter cooperii* and *Buteo platypterus*. What is it about their diets and feeding behaviors that might explain this difference?

4. How does *Chordieles minor* forage (find and catch food), and how is this reflected in its skeleton?
Figure 3. A Phylogeny of major bird lineages based on whole-genome DNA sequences. From E. D. Jarvis et al. December 2014. Science 346:1320-1331. The K-Pg boundary is denoted by the arrow. All orders of birds were in place by 50 Ma, denoted by the dashed line.
Appendix II

Bird information cards to be used by the students to gain more background knowledge on each bird species.

Ruffed Grouse

*Bonasa umbellus*

**Family**

The Ruffed Grouse belongs to the Phasianidae family. Phasianidae, the pheasant family, is a bird family that includes among its members the jungle fowl (from which the domestic chicken is descended), partridge, peacock, pheasant, and quail. Some classifications assign the turkey to Phasianidae, whereas several others place it in the family Meleagrididae. Phasianids are small to large, blunt-winged terrestrial birds. Phasianids are mainly terrestrial ground dwellers that move about mostly by walking, and may fly only short distances. Phasianids forage by digging and scratching the ground.

**Food**

Ruffed Grouse feed almost exclusively on vegetation, including leaves, buds, and fruits of ferns, shrubs, and woody plants. In fall, soft fruits and acorns become an important part of the diet. Ruffed Grouse’s ability to digest foods high in cellulose make it possible for them to survive harsh winter conditions in the northern part of their range, where they feed on buds and twigs of aspen, birch, and willow. Although insects and other invertebrates make up only a small part of the adult grouse’s diet, chicks 2 to 4 weeks old depend on this protein-rich prey.

**Behavior**

Thanks to their cryptic coloration and slow, deliberate movements, Ruffed Grouse can be difficult to spot as they forage on the forest floor or walk along the low branches of trees and shrubs to pluck berries and buds. When displaying for females or defending territory, the male grouse stands atop a log, rock, or low dirt mound with crest, ruff and tail erect, puffing up to nearly double its normal size and beating its wings to create a rapid-fire drumming sound. Although Ruffed Grouse are normally solitary, small groups of unrelated birds may form in fall or winter to take advantage of productive feeding spots.


Family
Common Nighthawks are part of the Caprimulgidae family. Birds of this family are commonly called nightjars, from their jarring cries, or goatsuckers, from the ancient superstition that they used their very wide mouths to milk goats. They are insectivorous birds that take flying insects on the wing, usually at night. During the day they sleep on the ground or perched, usually lengthwise, on a branch. Nightjars are protectively coloured in gray and brown and are sparrow to pigeon sized.

Food
Common Nighthawks eat flying insects almost exclusively. The Common Nighthawk hunts on the wing at dawn and dusk, opening its tiny beak to reveal a cavernous mouth well suited for snapping up flying insects. It often takes advantage of clouds of insects attracted to streetlamps, stadium lights, and other bright lights. Nighthawks eat queen ants, wasps, beetles, caddisflies, moths, bugs, mayflies, flies, crickets, grasshoppers, and other insects. They may also eat a small amount of vegetation. Though they forage in low light, they seem to locate prey by sight, possibly with the help of a structure in their eyes that reflects light back to the retina to improve their night vision. They occasionally forage during the day in stormy weather, but seem to never forage at night. Common Nighthawks may forage near the ground or water, or more than 500 feet into the sky.

Behavior
Common Nighthawks are most active from half an hour before sunset until an hour after sunset, and again starting an hour before sunrise (ending about 15 minutes after the sun comes up). They fly with looping, batlike bouts of continuous flapping and sporadic glides. Common Nighthawks are usually solitary, but they form large flocks during migration and males sometimes roost together. Large migrating flocks are most conspicuous in early evening, particularly as the birds gather above billboards and other bright lights to feed on insects. Both males and females feed regurgitated insects to their chicks.

Broad-winged Hawk
*Buteo platypterus*

**Family**
Broad-winged Hawks are a part of the Accipitridae family. This family encompasses many of the diurnal birds of prey, including the familiar hawks and eagles. It is one of the largest avian families. Members of this family span the globe, living in habitats as wide ranging as tundra, alpine meadows and rainforests. Accipitrids are diurnal birds of prey with broad wings, hooked beaks, strong legs and feet and sharp talons.

**Food**
Broad-winged Hawks eat mostly small mammals, amphibians, and insects. They only occasionally hunt on the wing. Their most frequent prey items are frogs, toads, and small rodents, but they have a broad diet that includes invertebrates, amphibians, reptiles, mammals, and birds (mostly nestlings and juveniles). Their invertebrate prey includes mantises, crickets, grasshoppers, caterpillars, ants, junebugs, click beetles, ground beetles, flies, spiders, earthworms, and crabs.

**Behavior**
Broad-winged Hawks watch for food from perches on tree limbs (often below the canopy and in the forest interior) as well as places such as utility poles near forest edges. When they spot prey, they swoop down to snatch it from the forest floor. Within the forest Broad-winged Hawks take short flights from branch to branch; they also soar in circles above the canopy during breeding season, probably in territorial defense. Courting birds perform sky-dancing displays in which they circle high in the air and then plummet toward the ground. They build nests at least half a mile from the next nearest Broad-winged Hawk pair. Although Broad-winged Hawks interact only with their mates in the breeding season, during fall and spring migration they form enormous flocks that often include other raptor species, sometimes totaling tens of thousands of individuals.

**Family**
Cooper’s Hawks are a part of the Accipitridae family. This family encompasses many of the diurnal birds of prey, including the familiar hawks and eagles. It is one of the largest avian families. Members of this family span the globe, living in habitats as wide ranging as tundra, alpine meadows and rainforests. Accipitrids are diurnal birds of prey with broad wings, hooked beaks, strong legs and feet and sharp talons.

**Food**
Cooper’s Hawks mainly eat birds. Small birds are safer around Cooper’s Hawks than medium-sized birds: studies list European Starlings, Mourning Doves, and Rock Pigeons as common targets along with American Robins, several kinds of jays, Northern Flicker, and quail, pheasants, grouse, and chickens. Cooper’s Hawks sometimes rob nests and also eat chipmunks, hares, mice, squirrels, and bats. Mammals are more common in diets of Cooper’s Hawks in the West.

**Behavior**
Cooper’s Hawks show the classic accipiter flight style: a few stiff wingbeats followed by short glides. But in pursuit of prey their flight becomes powerful, quick, and very agile, allowing the bird to thread its way through tree branches at top speed. Courting birds display by flying with slow wingbeats, then gliding with wings held in a V.


Greater Roadrunners are part of the Cuculidae family, otherwise known as the Cuckoo family. Most cuckoos are relatively large, blue jay sized birds, with long tails, strong feet, and strongly built bills. Most members of the family are arboreal, but some are terrestrial, including the Greater Roadrunner.

**Food**
Greater Roadrunners eat mostly animals, including almost anything they can catch: small mammals, reptiles, frogs, toads, insects, centipedes, scorpions, and birds. Roadrunners also eat carrion and prey on bird eggs and chicks. They kill rattlesnakes by pecking them repeatedly in the head. They slam large prey, such as rodents and lizards, against a rock or the ground multiple times to break down the bones and elongate the victim, making it easier to swallow. These opportunistic predators have also been known to grab birds from backyard feeders or nest boxes. In winter, fruit, seeds, and other plant material make up 10 percent of the roadrunner’s diet.

**Behavior**
True to its name, the Greater Roadrunner races along roads, streambeds, and well-worn paths, defending its large territory and chasing lizards, rodents, and insects. While on the move they startle and flush a meal by flashing the white spots on their open wings. Roadrunners can also jump straight up to snag insects, bats, and even hummingbirds in flight. Although agile on the ground, roadrunners don’t fly well. A threat may trigger a short, low burst of flight to seek a hiding place; otherwise, flying is limited to gliding from a nest or perch to the ground, or between perches.
Family

Caspian Terns are part of the Laridae family. The members of the bird family Laridae are seabirds that range in size from fairly small to large and heavy-bodied. They have long wings, stout bills and webbed feet. They are usually white below with a back that ranges from pale grey to black. The Laridae family is comprised of gulls, terns, and skimmers.

Food

The Caspian Tern’s diet is comprised almost entirely of fish. They will occasionally eat crayfish and insects.

Behavior

The Caspian Tern flies over water with its bill pointing down and plunges into water to catch fish.