**Title:**
A Case of a Warbler Eating Berries

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**Abstract:**
Warblers make up a taxon of birds that is adapted to eating small insects typically gleaned from plants or caught in the air or on the ground. While all warblers feed this way the eastern subspecies of the Yellow-rumped Warbler (*Setophaga coronata coronata*) has an adaptation that enables it to eat the fruits of the Bayberry plant (*Myrica pensylvanica*). This adaptation enables this species to winter farther north than other warblers as it is not dependant on insects for food. There are many ecological consequences of such an adaptation and this case provides an opportunity to discuss the importance of novel adaptations in nature with classes at any level.

This is a photographic case study. The photograph is the case. The point is to gather data from the photograph, draw inferences from those data, form and test hypotheses about those inferences. This can easily be done in the classroom at any level ranging from high school ecology to upper level college biology. Students must think of ways to explain their observations and you may be surprised at how many different concepts they will develop for themselves.

**Learning objectives:**

Students should develop certain skills working through case studies like this one. Their observational powers should develop as they learn to look beyond the first impression of the image and pick out details. They will make assumptions about what is happening in the picture and with guidance from the instructor will learn to frame those assumptions as hypotheses. Once they have developed these hypotheses they should be able to come up with tests that could disprove their hypotheses. Some tests may be done using information from the picture, others might need further information not provided. The important skill is to develop hypotheses and understand how to test them. Finally, students should learn something about the basics of evolution and the ecology of migratory birds.

**Timeframe:**

Preparation time for this case is minimal. The instructor should read through our instructions and think about how he or she wants to steer the class discussion. It may take time to distribute the photos to the class or if a projector is available simply show the photos at the front of the room. Running a case like this in class usually takes about 20 minutes, but can be expanded to a whole class period if the instructor wishes do do so.

**List of materials:**

The only materials needed are the photographs. A board to write down class ideas would be useful or students can write their ideas on paper.

All of the photos in this case study are available on EcoEd Digital Library as individual files, ***http://esa.org/ecoed/index.php?P=P_Folders_ViewFolder&FolderId=97***

**Procedure and general instructions (for instructor). REQUIRED.**

**Part I**

As with any photographic case study the first question to ask is "What do you see?" The class will certainly respond with "Birds." Some more observant students might notice that each bird has an insect in his mouth. If they don't, invite the students to examine the photograph more closely. Eventually, someone will notice the warblers are eating. This initial photograph is used for background information to show that warblers are a group of insect eating birds, the norm for the taxon. At this point, the students should be directed to answer the first set of questions.


Questions

1. What do the birds have in common?
2. What are the birds eating?
3. Why do you think they are eating insects?
4. What adaptations do you think these birds might have that help them eat insects?

**Part II**

Below is the principal photograph for the case study in which a Yellow-rumped Warbler (*Setophaga coronata coronata*) is feeding on Bayberry (*Myrica pensylvanica*) berries in New York City.

**Questions**

1. What do you see?
2. What do you notice about the berries?
3. What do you know about wax? Would you eat it? Why?
4. What do you know about warblers?
5. Why is the insectivorous bird eating berries coated with wax? (Hypothesis generation).

Again, ask "What do you see?" Unsuprisingly, the students will note, "A bird eating a berry." Students can now be directed to answer Question 2. They my need a little prodding to notice that they berries are "lumpy" looking. Unlike most berries the berries of the Bayberry bush are coated with wax giving them their odd appearance. Students may not pick up on this and could think that the berries are actually individual seeds or coated with fungus or a variety of other possibilities, but eventually you can get them to recognize that the coating is wax. Pointing out the white, pasty coating of the berries and asking students if they've ever seen berries like that before is an effective way to get students to recognize the unusual nature of these berries. Now students answer Questions 3, 4 and 5.

Wax is indigestible for most animals. “So if wax is indigestible, why would a bird eat the berries?” is an excellent question for students to ponder. Students readily leap to the conclusion that mutations have occurred and, in this case the conclusion is correct, but their thought processes can now be steered to recognize the adaptive value of such a mutation. This species of bird has a special adaptation that allows them to digest the wax setting them apart from other birds and opening a resource to them that other birds are unable to exploit.

This is a good point to ask the class if anyone knows anything about warblers. In our experience there will be someone who has some knowledge of warblers in about 50% of introductory biology classes at the college level. Responses such as “They are songbirds” (warble means to sing, of course), “they eat insects”, “they migrate”, etc are typical. Warblers as insect-eating birds are actually an example of niche partitioning in some textbooks. Well that’s an interesting point. Why is an insect-eating bird, eating berries? The answer is the mutation cited above that a special adaptation allows them to do so. The evolution from an insect-eating bird to a berry-eating bird is a significant evolutionary leap and excellent discussion topic. Yellow-rumped Warblers are primarily insect eaters, but are able to exploit the berries when the temperature drops and insects disappear.

A subsidiary point that could be quite interesting here is the issue of why there is wax on the berries in the first place. If the purpose of producing a berry is to bribe birds to disperse seeds by eating them what could be the evolutionary advantage to a plant in coating them with an undigestible coating? This is a great question to make students think and there are two good answers that they might come up with. Students will mostly suggest that the indigestible wax protects the berries from digestive enzymes. This is an reasonable suggestion and can lead to a discussion about evolutionary interactions and the Red Queen Hypothesis. Another very good response is much more difficult for students to come up with because it requires that they step out of the direct subjects at hand and think about other organisms not in evidence. If you ask students to think about the wax as a response to other animals that might eat the berries they will probably think about small mammals. Asking about the most diverse and/or populous group of organisms on the planet will get them to suggest insects. Either of these groups will eat not just the berries, but will grind up the seeds as well since they chew their food while birds don’t. It is an entirely reasonable hypothesis that the wax coating is a defense against these animals that would destroy the seeds rather than dispersing them.

**Part III**

Once the photograph has been discussed and many different possibilities have been suggested by the class it's time to refocus them and bring them back around to the primary topic at hand. There is no reason why this needs to be any one thing and instructors can certainly choose to focus on different issues depending on the needs of their syllabi, but for us the focus is on the physiology and ecology of bird migration. Focusing on the metabolic needs of migration and the connection between physiology and ecology is food.

The availability of food brings up an interesting point directly connected to one that the students may have mentioned earlier, warblers are migratory. Most species travel from their breeding grounds in the north United States and Canada to wintering grounds in South and Central America. Now there's a whole conversation about why birds migrate at all. It is an event that puts a tremendous physiological stress on them, but appears to be worthwhile to take advantage of the abundance of insects to feed their young with in the northern summers.

How do the berries fit into this picture? Bayberries, like most berries, emerge in the late summer and fall. Since most animals can't eat them they often persist through the winter. The ability to exploit the bayberries means that Yellow-rumped Warblers have an extra, high-energy food source to fuel the metabolic demands of an extended migration. Another series of questions can help elicit observations and hypotheses about the relationship between the exploitation of bayberries and the warbler's migratory patterns.

Questions

1. How does the information about migration change your thoughts about why the birds might be eating the bayberries?
2. Bayberry bushes produce seeds in late summer and fall. Does this fact alter or support your idea about why the birds eat their berries?
3. Why do you think the warblers are eating bayberries and not some other berry?
4. How does the ability to eat bayberries alter the migration pattern of the warbler?

Student Responses

Of course many student responses are possible and all serious responses should be discussed and encouraged in terms of the data at hand. One of the most important opportunities at this point is to guide student back to information about biological molecules from the beginning of an introductory biology class. Eventually students will recognize that the wax coating of bayberry seeds is a lipid and that lipids are highly concentrated energy sources. Once this connection is made students quickly recognize the importance of ATP synthesis to migration and the importance of this particular species to that process. It usually takes a bit of work on the part of the instructor to stimulate recollections about the process of cellular respiration and metabolic thermogenesis, probably a new term for students, but not a new concept. Students

will quickly see what an important resource bayberries are for fueling migration and usually make the connection to suggest that birds using them can tolerate colder temperatures than similar species and wonder if they really need to fly all the way to South America leading to the concept discussed in Part IV.

Student responses often include questions rather than observations or inferences. One of the most common questions is about what the birds eat the rest of the year if bayberries are only available in the fall. The answer is that they primarily eat insects and it emphasizes the importance of the bayberries as a migration/winter food source. Students sometimes ask if young birds learn to eat the bayberries from their parents. This is a good question and , as far as we can determine one that has not been answered through peer-reviewed research. It can certainly be worth discussing the possibilities of young birds following their parents to learn migratory routes and the fact that they would not have been fed bayberries in the nest. There is not a cut and dried answer to this question and we do feel that it's important for students to realize that there are questions in biology that have yet to be answered. In our experience it has never occurred to students to ask why these birds need to migrate at all and this can be a very useful question to pose to a class. Bringing up issues of the genetic basis for behavior, distribution of resources and seasonality can give students a much greater appreciation for the complexity of ecological problems and the importance of the interconnectedness of different environmental elements.

As a supplement to the case we also provide the following close-up photograph of bayberries making the waxy coating clearer to students who might ask about it. In this close up view of bayberries you can clearly see a whitish waxy coating. Bayberries are boiled to melt this wax for use in bayberry-scented candles. One of the berries has been nibbled by a herbivore, most likely a insect. You can see from thenibbled surface how the wax forms a layer across the surface. Clearly the berry was distasteful to the (presumed) insect that was eating it as only a small portion of a small berry was devoured. Yellow-rumped Wablers swallow the berries whole and are then able to extract nutrition from them while distributing the seeds of the plant.

(You can see from the nibbled surface how the wax forms)

**Part IV**

There's an even more significant implication to the extra food source though. With a high-energy food source present in North America (Bayberry grows all along the eastern seaboard in coastal environments) Yellow-rumped Warblers are able to winter as far north as New York, reducing the distance they have to travel and the physiological stress they endure drastically. Providing the information on the distribution and fruiting times of Bayberry to the class will allow them to come up with the ideas that the migration can be reduced as part of the class discussion.

Questions

1. Is there an advantage to migrating to the east coast rather than to South America?
2. What is that advantage?
3. Why is a shorter migration an advantage?
4. Would this advantage affect survival rates?
5. Would the increased energy expenditure in a cold climate counter balance the reduced energy expenditure of the migration?
6. Are there other advantages besides energy balance?

Students will typically answer, “yes, they have to fly a shorter distance” to questions 1 and 2. This response can easily be reconciled into an energy issue in question 3. It requires less energy to fly a shorter distance thus giving the birds a survival advantage. Students then have to recognize that the climate in North America is colder than that in South America and that maintaining homeostasis in a cold climate requires a greater expenditure of energy for an endotherm than it does in a warm climate. The students can then design a variety of experiments, probably using mark and recapture techniques in the field, or metabolic rate calculations in the lab to determine whether this this advantage is real or not. With their current level of uncertainty they can search for alternative advantages to the shorter migration like reduced exposure to predation.

The picture of a Yellow-rumped Warbler eating bayberries enables a class to develop significant understandings about the ecology of migration, feeding strategies, evolution and adaptive radiation. In general, we have found that this photograph is very effective as a capstone after these concepts have been taught in lecture to provide students an opportunity to apply what they have learned and internalize it. With an advanced upper level class, however, it may be used very effectively to allow students to develop and instigate topics of study. By asking questions and seeking answers they will determine the need to understand the nature of these subjects.

**Objectives of the Case :**

When the students have finished this case study they will

1. have increased their ability to examine photographs for details. Often students think that the pictures are interesting but don’t go beyond this idea. Be forcing the student to notice small details of the photographs, they will now look at other photographs with a keener eye.
2. have created a hypothesis about why an animal behaves in a certain way.
3. have to rethink their original hypothesis in light of new information. Since all the information is presented as photographs, students have to hone their observational skills.
4. have developed their abilities to connect different concepts in biology and understand the importance of the relationships between them.
5. have gained confidence in their own abilities to gather and interpret data.

**Part V. Classroom Management**

The use of photographic case studies in the classroom is really up to the instructor. This case makes an excellent summary to the ecology-evolution section of an introductory biology course. It also makes an interesting introduction to various topics in an upper level ecology or evolution class.

One of the most effective methods to presenting the case in class is to start of by simply listing observations on the board. A separate list of inferences allows students to connect their observations together to form hypotheses about what is going on. Listing student hypotheses is the next logical step.

This case can be presented in a number of ways. Our preference in to present the photograph using power point and turn the case into a class discussion. If you prefer the photograph and questions can be printed out and given to students individually or in groups to work out on their own. Hybrids between these two models work well also. An advantage to presenting the picture with powerpoint is that you can use the felt pen function to highlight the aspects of the slide students are engaging with on screen or to draw their attention to important things they might be overlooking. The principle thing is to keep the students thinking; constantly ask questions, find the logic in their conclusions and make them evaluate and reevaluate their ideas. In the end summarize the concepts they have developed on their own and point out to them that they deduced these principles, not you. They will put together a coherent, scientifically sound story with only a bit of coaxing from you.

**Procedure and general instructions (for students).**

The students need nothing but eyes and brains.

**Reference list**

Borgmann, Kathi L.; Pearson, Scott F.; Levey, Douglas J.; Greenberg, Cathryn H. 2004. Wintering Yellow-rumped Warblers (*Dendroica coronata*) track manipulated abundance of *Myrica cerifera* fruits. The Auk 121(1):74-87, 2004

http://www.allaboutbirds.org/guide/Yellow-rumped_Warbler/lifehistory

http://www.borealbirds.org/birdguide/mig_map_main.shtml