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Owl Web: Using Owl Pellet Dissection as a Hands-On Introduction to Nutrient and Energy Webs

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The goal of this laboratory exercise is to provide a hands-on introduction to food webs, nutrient cycles and energetics. Combining owl pellet dissection and a low stakes food/energy web activity allows students to observe and handle tangible evidence of energetics before constructing a more complete picture. It also provides an opportunity for students to incorporate alternative food and nutrient webs into their concept of energy flow through an ecosystem. This exercise is designed for students at multiple levels and to work at a range of class sizes.

Keywords: owl pellet dissection, food webs, nutrient cycles, energetics

Introduction

Owl pellet dissection has frequently been used in many courses as a way to introduce and expand on basic ecological concepts such as predator prey interactions, food web energetics, biotic and abiotic nutrient cycling, and community structure (Bandelier 1993, Winkelsas 2000). Our laboratory exercise takes this one step further and combines the owl pellet dissection with a structured food / energetics web project. Although connections have been made between dissections and food webs (Timmons 2004), our exercise extends beyond the paper and pencil homework construction into a peer-guided, low-stakes activity. It is also designed to pull together a number of concepts and incorporate active modalities in the learning experience.

Finding and identifying the various prey items in the owl pellet encourages scientific thought and critical thinking and allows the student to see parts of a food web first-hand. The overall objective is to incorporate a broader spectrum of organisms and abiotic factors into the traditional food web, perhaps challenging a pre-conceived notion that energy flow is simple and interactions are in only one direction – up trophic levels.

These objectives can be met at a range of educational levels and class sizes. This laboratory exercise is intended to be flexible, so that instructors can adapt it for their specific needs. For high school students, a basic food web can be drawn. More advanced students can include detritivores, so the owl pellets themselves can be incorporated into the food web and abiotic and biotic interactions can be discussed. In upper level college classes, tooth morphology (Hager and Cosentino 2006) can be used to get a more accurate picture of the owl's diet. It is also possible to see how the owl pellets can be used to determine local and global environmental change (Thiam et al. 2008).

Once the owl pellets have arrived and equipment has been gathered, set up should take approximately 10 minutes. The exercise and discussion should take two to three hours. The exercise can be modified to fit shorter class periods by having the dissection on one day and the follow up exercise and discussion during the following class period.

Student Outline

What is an owl pellet? It is a compact mass of bones, feathers, fur, exoskeletons and other undigestible animal parts that an owl regurgitates after eating a prey item. They are useful because they allow us to examine what is in an owl's diet without having to capture or kill the owl. We will use the contents of the pellets we dissect today to construct a food web and inform our discussion of that food web.

Our owl pellets were purchased from a biological supply company and have been autoclaved. They are therefore sterile. If you have fur or feather allergies, you may need to use gloves. Otherwise handling the pellets is safe. Submerging the owl pellets in water prevents air-borne fur, which is unpleasant to breathe. It also makes it easier to extract the bones from the pellet. Be careful with sharp forceps and dissecting needles. Bone and tooth fragments can also be sharp.

In this laboratory you will spend between one and one half to two hours dissecting an owl pellet and identifying all of the bones in it. Be sure to focus on identifying bones (especially skulls) and writing down what you have found. The first step in this dissection is to measure your pellet and make sure you know the geographic region from which your pellet originated.

Name: _____

Procedure:

1. Measure the length and width of your owl pellet in **centimeters** and determine the weight in **grams**.

   Length _____ Width _____ Weight _____ Origin _____

2. Place your pellet in the round glass dish and cover it with water.
3. Slowly begin to tease the pellet apart, looking for bones, teeth, and claws. Place these onto a paper plate as you find them.
4. Using the provided keys, determine whether each animal part came from a mammal, bird, amphibian or reptile and record you data in Table 1.

Table 1. Types of animal parts and quantities found

Prey Found	Number of Bones Found
Mammal	
Bird	
Amphibian	
Reptile	
Other (type)	

5. For the **mammal** bones only, determine what type of bone you have found and record your data in Table 2.

Table 2. Mammal bones found in your pellet.

Bones Found	#	Bones Found	#
Femur		Humerus	
Ulna		Fibula & Tibia	
Radius		Pelvis	
Scapula		Ribs	
Vertebrae		Various Foot Bones	
Mandibles (Jaws)		Skulls	
Claws			

Notes:

6. From the mammal skulls (a complete skull includes the detachable lower jaw that may have split into right and left halves), determine how many of the following mammals are represented. Record your data in Table 3, blank spaces are for additional/alternative species.

Table 3. Mammalian skulls found.

Prey Found	Number of Skulls Found
Vole	
Mole	
Shrew	

7. Compile the data from the entire class in Table 4 below. Fill in any organisms we found that are not listed below.

Table 4. Compiled class data.

Prey Found	Vole	Mole	Shrew	Others*
TOTALS	#	#	#	#
Total number of prey items found:				
Total number of pellets dissected:				
Average number of prey items per pellet:				

*All other species found should be keyed out and placed in this table. If you have owls that fed on a diverse population, students may need additional space.

Notes:

Questions

1. In reference to your compiled class data, what type of prey is most abundant?

2. What type of prey is least abundant?

3. Is it possible that the prey identified from the pellets does not reflect the true mammal population in the wild? Why or why not?

4. Assuming that the barn owl regurgitates one pellet per day, how many prey items would the owl that produced your pellet consume per year?

5. Why do we use mammal skulls to determine the number of mammals present in the owl pellet? Why are other bones not used?

Class Exercise

1. Your instructor will hand you a food web component with a description.

2. Following your instructor's directions, place your component on the board with arrows indicating the direction of energy or nutrient flow through the food web. For example, an arrow connecting a mouse and an owl would go from the mouse to the owl showing that the mouse provides energy to the owl. Mouse → Owl

3. Use a blank page to draw the entire class food web and to take notes.

Materials

The supply list is given for students working as individuals or in pairs. If each student has their own owl pellet, encourage them to work in pairs for identification of the bones and skulls. Appendix A gives a list of suppliers.

Supplies for 25 students:

Part 1: Dissection

- 12 to 25 owl pellets (one per pair of students or one per individual depending on class size, time and specific course goals)
- 25 to 50 dissecting needles (some students find using two needles at once useful)
- 25 pairs of forceps
- 25 shallow dishes for submerging pellets in water (this allows each student in a pair to dissect half of the pellet, or their own pellet)
- Squirt bottles or other low velocity water source per pair of students (tap water works well)
- 12 to 25 paper plates for extracted bones (match pellet numbers)
- 12 to 15 Bone and Tooth Keys / Identification Guides. The easiest way to create a student bone and tooth identification packet is to print guides for free from Carolina Biological (Appendix C) and use the Hager and Cosentino (2006) tooth key.
- 25 small rulers
- 5 balances
- 2 to 5 gallon waste bucket(s) for pellet parts as fur clogs sinks effectively.

Optional

- Magnifying glasses and/or dissecting microscopes (up to 1 per pair) to look at tooth and bone morphology for identification purposes.
- Books with more detailed keys (Appendix C) and actual skulls/skeletons of expected genera for more detailed identification of small mammal genera. Skulls and skeletons can be extracted from pellets as students find good examples and saved for succeeding classes.

Part 2: Food/ Energy/ Nutrient Web

- Cut up list of food web components (Appendix B) that will go in the class food web on the board—do not forget the owl and the sun! The food web components can be adjusted to match the origin of the owl pelts or any location you wish to focus on.
- Black or white board
- Colored chalk or markers (lots so that more than one student can be drawing/writing on the board at a time).

Notes for the Instructor

Part 1: Owl Pellet Dissection

As written, this is an introductory level, single three hour exercise. Depending on student level, you can stick to broad generalizations like rodent, shrew, mole and bird (as shown on the Carolina Bone Identification Chart) or go into details as far as is appropriate. For example, an ecology class looking at population dynamics could use the tooth key presented in Hager and Cosentino (2006) to determine rodent genera. The example directions provided above are for the basic college introductory/non-majors class.

Class should spend between 45 minutes (75 min class to two hour lab) and 1.75 hours (three hour lab) dissecting and identifying all the bones in their owl pellets. Be sure students focus on identifying bones (especially skulls) in the last 15 to 20 minutes, since groups that get really into the dissection sometimes miss the identification step.

Have the students identify as many bones as possible as this is useful for anatomy lessons and helps engage more squeamish students.

Most importantly, identify all the mammal skulls as accurately as possible. Be sure that the students understand why the skulls are considered definitive identification of mammals. We use the skulls primarily because each prey item only has one. Also with other bones such as ribs or femurs it is hard for students to identify beyond rodent vs. bird etc correctly. We focus on mammal skulls as well because genera can be separated based on tooth length and morphology.

Identification of small mammals should be constrained to genera or broad category unless species identification is a major goal of the course (i.e. a Mammalogy or graduate level class). More detailed identification of bones and skulls takes additional time and can lead to a lack of time for the web construction activity. Hager and Cosentino's (2006) method using the curvature of incisors works quite well, if you have BOTH the upper and lower incisors. With only an upper or a lower the information will be inconclusive. This can cause a positive confusion for students making them deal with the types of missing data and resulting hypotheses encountered regularly in scientific research.

For professors and TAs who are unfamiliar with the mammalian genera that commonly occur in owl pellets there are a number of good resource books. Most mammal field guides contain drawings or photographs of representative skulls. *Animal Skulls: a Guide to North American Species* (Elbroch 2006) has excellent images of skulls and is not restricted to mammals. However the index is somewhat rudimentary, and does not include scientific names, which makes it difficult to use with the Hager and Cosentino (2006) key. The Animal Diversity Web: Smithsonian Diversity of Life Pages, and other World Wide Web resources can help with this (Appendix C).

Clean Up Caveats

- Check the local laws regarding disposal of bones and fur. In some states the dry pellet remains can go directly in the trash, but in other places it may need to be disposed of as some degree of biological waste.
- Wet fur and bones should never be poured into sinks, since they will clog. Buckets (two to five gallon range) make good disposal containers.
- Students should stop work in time to clean their own glassware and other dissecting equipment.

Safety

- Owl pellets bought from a biological supply catalog will be autoclaved and sterile, but students with fur or feather allergies may need to use gloves.
- Submerging the owl pellets in water prevents air-borne fur, which is unpleasant to breathe.
- If you collect your own pellets, autoclaving is recommended to avoid the potential of zoonoses. Hantavirus is not a concern so long as pellets are autoclaved. Among mammalogists and others with occupational exposure, antibodies to hantavirus and its relatives are statistically nonexistent; four of 757 high risk people tested (0.5 %) carried antibodies (Fulhorst et al 2007; Hafner 2007).
- Otherwise safety concerns are those routinely found when using sharp objects and in the lab or classroom where you are conducting the exercise.

Data Analysis

Pull together the class data set to examine the dietary population in your set of pellets (example has 13 pellets, Table 4 example section). The example provided is for an introductory class including non majors.

Additional Data That Can Be Compiled

To examine the relationship between pellet size and prey found use Table 5. Once all students have tallied this for their pellet the data set can be examined for correlations between numbers of prey items and pellet size or pellet size and type of prey item or both.

Questions can be answered in class/lab or as homework depending on available time. Additional questions are provided below

Additional Questions:

- Were all of the bones and fur from an individual prey item in the pellet? i.e. if you had a mouse in your pellet did you find all its bones? How would you tell?
- Why do you think you saw the particular composition of bones you found in your pellet?
- Is there a correlation between pellet size and the number of prey items in the pellet?
- Is there a correlation between pellet size and the type of prey item in a pellet?
- Which prey items make up the largest portion of the diet (this is a combination of abundance and weight)? Why would this be a favored food item?

Ideas for More Advanced Students

- How does tooth morphology change across rodent genera?
- Students can be asked to conduct a variety of statistical tests with the size and weight of the pellet and the number of prey items in each pellet.
- If you can acquire pellets from multiple regions, additional mathematical comparisons of genera composition and energetics can be calculated.

Part 2: The Web

- Draw (or write) the sun and an owl on the board. Have the organisms and ecosystem components you are using for the web (Appendix B) ready for selection in a hat or other receptacle.
- Have each student pick out one or two web components (In a class of 25, having one component per student works well. In smaller classes or larger classes with multiple groups having each student pick two or three components also works well.)
- For small classes (<15), or younger classes, with lots of time each student can add their organism/component to the food web on the board individually.

Table 5. Relationship between pellet size and prey found.

Group	Pellet size	Number Prey items	Type of prey items
Student names here	Can be just length and width or the pellet can be weighed		

- For medium sized classes (~ 30 students) have multiple writing utensils so students can add their components a few students at a time (in an orderly fashion). Sending multiple students to the board at one time allows them to help each other figure out how the system fits together.
- Break larger classes (50 + students) into groups of 25-30 to construct multiple webs (using different sets of organisms) and then compare those food webs. Using the sun and detritus as components makes for nice connections to energy flow and nutrient cycles.
- Ask the students to add the component they have to the board and connect the components with the appropriate arrows. It may take several students before there is a connection to the owl or the sun.
- Encourage discussions of arrow placement and connections within the system and allow them to self and peer correct. Ask where we could add more arrows and whether arrow directions are correct. Be sure to make these corrections on the board.
- As more organisms and environmental pieces are added students may need to return to the board to add arrows. Arrow directions should follow energy or cycle flow. For example to follow energy flow, an arrow connecting a mouse and an owl would go from the mouse to the owl showing that the mouse provides energy to the owl. Mouse → Owl.
- Food, energy, nutrients, biomass, water and any other ecological and energetic diagrams can be drawn. Depending on the goals of the class different colors could be used for each cycle or for the types of energy and nutrient transfer being focused on.
- Once all students have finished drawing on the board have the class step back and look at the picture. It should appear complex and messy!

Guiding/Follow-up Questions

1. What does this look like, what have we done?
2. Are there any connections missing? Again this is self correction/ peer correction time.
3. Is there anything unusual? (Arrows going the wrong way can result in worms eating eagles and other things students should be able to spot.)

After these questions the discussion is driven by your course goals. As written this exercise is open ended. You will want to think about what sort of conclusions or lack of conclusions are appropriate for your classroom situation. Depending on the surrounding course goals and time constraints it can be used to instigate a through line theme for the course, stand on its own making the points of integration and complexity in food and energetic interactions, or a number of variations in between.

Additional Food Web Assignment (Homework)

Placing the owl at the highest trophic level, create a food web using 10 of the following items: vole, deer mouse, mole, weasel, shrew, snake, robin, frog, salamander, spider, grubs, earthworms, centipedes, crane fly, seeds, plants, roots. (See the descriptions below if you need help.)

- Shrews (15-30 g) and moles (35-75 g) are insectivorous mammals. They have long, flexible, highly sensitive snouts.
- Voles (35-65 g) are herbivorous mammals.
- Deer mice (25-35 g) are omnivorous mammals.
- Weasels (25-116 g) are carnivorous mammals.
- Snakes eat anything from insects to small owls, depending on the size of the snake and the prey item.
- Robins (~77 g) are invertebrate-eating birds.
- Grubs, earthworms, centipedes and crane flies are invertebrates that eat detritus.
- Frogs and salamanders live in wet places and generally eat invertebrates.
- Spiders are insectivores

Sample Results

4. Using the provided keys, determine whether each animal part came from a mammal, bird, amphibian or reptile:

Table 1. Types of animal parts and quantities found.

Prey Found	Number of Bones Found
Mammal	50
Bird	6
Amphibian	
Reptile	
Other (type)	

5. For the mammal bones only, determine what type of bone you have found:

Table 2. Mammal bones found in your pellet.

Femur __3__	Humerus_____
Ulna_____	Fibula & Tibia____
Radius____	Pelvis____
Scapula__1_	Ribs_LOTS_
Vertebrae__7_	Various Foot Bones ____
Mandibles (Jaws) __3__	Skulls __4__
Claws ____	

6. From the mammal skulls (a complete skull contains the detachable lower jaw that may have split into right and left halves), determine how many of the following mammals are represented:
7. Compile the data from the entire class in the Table below, fill in any organisms we found that are not listed below:

Table 3. Mammalian skulls found.

Prey Found	Number of Skulls Found
Vole	2
Mole	1
Shrew	0
Mouse	1
Bird*	1

* Students often want to include any bird skulls found. There is no reason to exclude them from the count of skulls found. We are not aware of any simple guides to identification of bird parts in owl pellets.

Table 4. Compiled class data.

Prey Found	Vole	Mole	Shrew	Mouse	Rat	Chipmunk
TOTALS	11	1	2	7	1	3
Total number of prey items found: 25						
Total number of pellets dissected: 13						
Average number of prey items per pellet: 1.9						

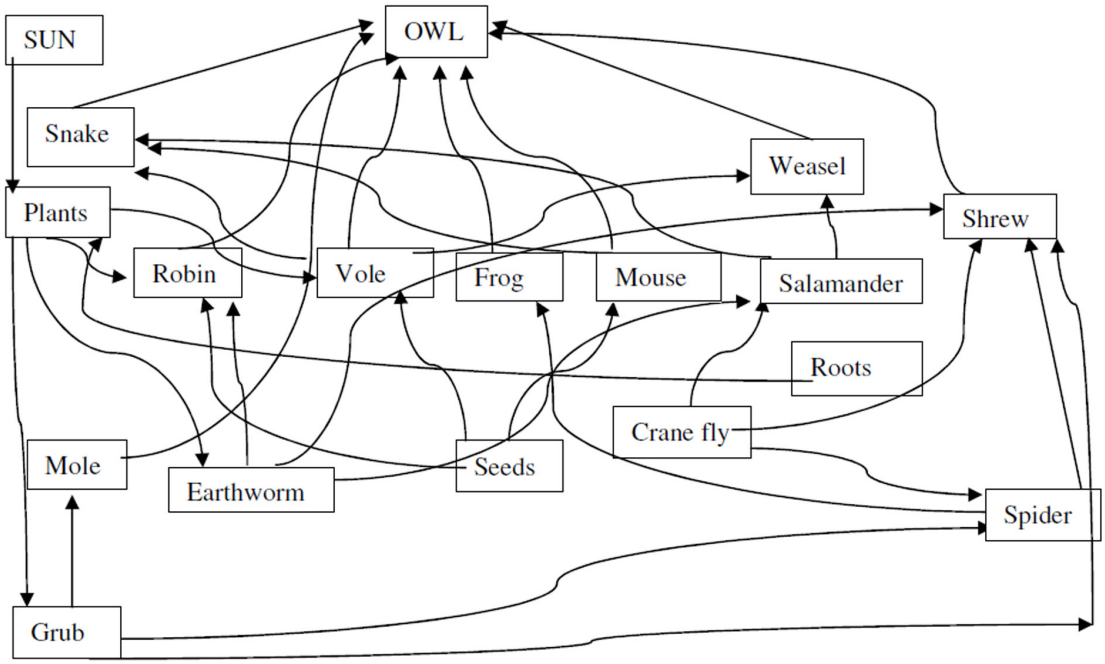

Figure 1. A sample web. Note that by adding detritus, a stream, or humans to this web we could easily change it from a tale of energy/matter flow to one of larger ecological connections.

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About the Authors

Katherine K. Thorington received her B.A. in biology from Mount Holyoke College, South Hadley, MA, in 2000 and Ph.D. in Biology from Wake Forest University, Winston-Salem NC, in 2008. She won the Anna M. Jackson Honorarium from the American Society of Mammalogists for her dissertation research on "The Role of Kinship in the Winter Aggregation Behavior of Southern Flying Squirrels (*Glaucomys volans*)" in 2008. Katherine is Park Naturalist for Historic Bethabara Park in Winston-Salem, NC and helped the park publish a park specific field guide. As a Visiting Assistant Professor of Biology at Salem College, Winston-Salem, NC, she has taught courses in ecology and research methods for majors and general biology and environmental science for non-majors. Her current professional interests include animal behavior and ecological research and the development of independent and naturalist led inquiry based public outreach programs and materials that get students of all ages outside exploring their environment.

Meghna B. Ostasiewski received her B.S. in Biology and minor in Secondary Education from Wake Forest University in 2000. After three years of teaching Biology at Woodbridge Senior High School, she returned to Wake Forest to earn her M.S. in Biology in 2005 and is currently a Ph.D. candidate doing her dissertation work on the advantages of sexual reproduction in evolving yeast populations. Meghna is currently a teaching assistant for the Genetics and Molecular Biology course, which is required for all biology majors. Her current professional goal is to teach introductory and upper-level Biology courses to college students using hands on and inquiry based learning.

Appendix A

Supplier Information

Carolina Biological Supply
2700 York Road, Burlington, NC 27215-3398
800.334.5551
www.carolina.com

Ward's Natural Science
PO Box 92912
Rochester, NY 14692-9012
800-962-2660
www.wardsci.com

Fisher Scientific
3970 John's Creek Ct. Ste. 500
Suwanee, GA 30024
800.766.7000
www.fishersci.com

Appendix B

Food Web List

	Creature/ Factor	Description
1	Sun	External Energy Source
2	Owl	Nocturnal Carnivore (bird)
3	Fox	Nocturnal Carnivore (3-14 kg mammal)
4	Snake	Diurnal Carnivore (reptile)
5	Weasel	Carnivore (25-116 g mammal that specializes in eating smaller mammals but will eat birds and eggs when mammals are scarce)
6	Detritus	Dead stuff
7	Earthworms	Detritivore
8	Crane Fly	Detritivore (aquatic insect larvae)
9	Centipedes	Detritivore/Carnivore
10	Grubs	Herbivore
11	Butterfly	Herbivore
12	Squirrel	Omnivore (338-750 g mammal)
13	Deer mouse	Omnivore (25-35 g mammal with large ears and eyes)
14	Vole	Herbivore (35-65 g mammal with small ears and heavy skull)
15	Spider	Insectivore
16	Frog	Insectivore (amphibian, lives in wet places)
17	Salamander	Insectivore (amphibian, lives in wet places)
18	Mole	Insectivore (35-75 g mammal with long, flexible snout)
19	Shrew	Insectivore (15-30 g mammal with long, flexible snout)
20	Roots	Nutrient gathering organs - underground; a good connection to nutrient cycles i.e. carbon cycle
21	Blue Jay	Omnivore (65-109 g bird)
22	Robin	Omnivore (~77 g bird)
23	Sunflower	Primary producer
24	Apple Tree	Primary producer
25	Clover	Primary producer
26	Stream	Water source
27	Sunflower Seeds	Propagule
28	Oak tree	Primary producer
29	Acorn	Propagule
30	Apple	Fruit

Appendix C

Bibliography of Instructor Resources for Bone and Skull Identification and Food Web Help

For additional food web organisms, images of live organisms, organisms native to your area, or more detailed diet information explore the following:

- Animal Diversity Web: **http://animaldiversity.ummz.umich.edu/site/index.html**
- Smithsonian Diversity of Life Pages: **http://www.mnh.si.edu/explore/diversity.htm**
- Specifically, the Smithsonian North American Mammals: **http://www.mnh.si.edu/mna/**
  This is an interactive tree of life way to navigate to species accounts of different mammals and includes pictures of skulls and teeth.

Bone and Tooth ID resources

- Carolina Bone Identification Chart **(http://www.carolina.com/category/teacher+resources/dissection+activities+and+resources/owl+pellet+interactive+database.do)**
- Elbroch M. 2006. *Animal Skulls: A Guide to North American Species*. Stackpole Books. Mechanicsburg PA.
  - ISBN-10: 0811733092
  - ISBN-13: 978-0811733090
- Hager, S.B. and Cosentino, B.J. 2006. An Identification Key to Rodent Prey in Owl Pellets from the Northwestern & Southeastern United States: Employing Incisor Size to Distinguish Among Genera. The *American Biology Teacher,* Online Publication.
- Roest A. I. 1991. *A Key-Guide to Mammal Skulls and Lower Jaws.* A nontechnical introduction for beginners. Mad River Press, inc. Eureka CA.
  - ISBN-10: 0916422712

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