Working the Night Shift – Biometric Clues (Western U.S.)

EXPLORATION QUESTION

"Why do we need to study bats and what methods can we use?"

MATERIALS

- Toothpicks (cut to size)
- Bat models or lunch bags with paper clips/beans/sand inside
- Metric rulers
- Metric scales (less than 30 grams)
- Latex, vinyl, or cloth gloves
- Student Inquiry, Instruction, and Evaluation Sheets
- Bat Survey Data Forms
- Dichotomous Key
- Identifying Features (table)
- Clue cards for each bat species
- PowerPoint presentation (optional)
- PowerPoint narrative (optional)

OVERVIEW

Students will learn and perform data collection techniques used in the field by bat biologists. They will measure and weigh "bat models," record data, and determine bat identification by using data collected, clue cards, and a dichotomous key. Students will also learn about White-Nose Syndrome and other threats to bats.

VOCABULARY

Biometric, calcar, endangered, extinction, forearm, fungus, harp trap, hibernate, membrane, mist net, species, tragus

GROUP SIZE

Any

AGE

13 and above (variations included for younger and older students)

Background

In general, bats are difficult to study because they are active at night, extremely fast fliers, roost in inconspicuous places (like caves and cracks in bridges), and they can move great distances in short periods of time. For these reasons, one of the greatest limitations to the conservation of bats is a lack of information on basic bat biology and ecology.

Although bats account for almost a quarter of all mammal species (there are more than 1,300 species of bats worldwide), bats are by far the least studied of all mammals. Bats occupy almost every habitat in the world eating tons of insects nightly, pollinating flowers, and dispersing seeds that grow new plants and even trees. Bats are our most important natural predators of night-flying insects consuming mosquitoes, moths, beetles, crickets, leafhoppers, chinch bugs, and much more! Many of these insects are serious crop or forest pests, and others spread disease to humans or livestock. Every year bats save us billions of dollars in pest control by simply eating insects. All but four of the 47 bat species found in the United States and Canada feed solely on insects. The remaining species feed on nectar, pollen, and the fruit of cacti and agaves in southwestern deserts.

Are bats in trouble?

Bats are in decline nearly everywhere they are found. Bat numbers in the United States and Canada have declined dramatically as a new disease, White-Nose Syndrome (WNS), has killed over six million bats in just six years. This disease is killing bats as they hibernate in caves and mines. Named for a cold-loving, white fungus typically found on the faces and wings of infected bats, WNS causes bats to awaken more often during hibernation. As a result, they use up their stored fat reserves which are needed to get them through the winter. Affected bats often emerge too soon from hibernation and are seen flying around in winter. These bats usually freeze or starve to death. More than half of the bats that live in the United States hibernate in caves and mines to survive the winter. Four of these bats are federally endangered (Indiana, gray, Virginia and Ozark big-eared bats) and live within or near WNS-affected areas.

The impact of WNS is frightening! Up to 99% of bats in some WNS-infected populations die within a few years. Little brown bats, once the most common bat in the northeastern United States, may be in danger of regional extinction within the next 15 years. Yet, WNS is just one of many threats that face bat populations. Other threats include habitat loss, pesticide use, wind energy development, oil and gas exploration, residential and industrial development, disturbance of hibernating bats, and improper eviction of bats from buildings. There is an urgent need to protect our bats!

In the United States, nearly 40 percent of our bats are endangered or are considered at risk. For example, gray bats were among our most abundant mammals just a century ago. Now, they are federally endangered which means they are in danger of extinction within the foreseeable future throughout all or a significant portion of their range.

How do we learn about bats?

One way that bat biologists gather information about bats is by conducting surveys. Surveying bats helps us learn what bat species are living in a given area (during a particular season) and how their populations are doing. By monitoring bats we can discover the factors that are important for their survival and identify which species need action now. We can also learn which areas are important for bats and need to be protected. When surveys are conducted year after year, biologist can detect increases or decreases in the size of a bat population. This long-term monitoring may be critical to understanding the overall impact of WNS and other threats to bats.

Bat biologists often conduct annual surveys to learn about bats by using mist nets, harp traps, or by observing bats in caves during hibernation. These types of studies allow easy standardization of data collection, hands-on examination, and reduce the chance of misidentifying species. Some species of bats can be difficult to identify and scientists must use a variety of characteristics to determine a bat's species. Your students will have a chance to hone their identification skills by learning some of these characteristics and by using a dichotomous key to learn others.

How do scientists tell one type of bat species from another?

To identify a bat, it is necessary to recognize the features that distinguish one species from another. Before you can give a bat a species name, you must first sort features of the animal into groups of similar and dissimilar traits. Biologists collect biometric data (measuring right forearm lengths, weighing bats, observing fur color, etc.) to identify bat species. This can be done very quickly by using a dichotomous key. Such keys include minute details about shapes and sizes of the parts of organisms that are being keyed out. Most bats that are found in the United States are not difficult to sort and identify into basic types when you know what characteristics to focus on. Others, like myotis species, are difficult to distinguish and morphological measurements are a necessity. And in some cases, biologists may even have to resort to genetics to determine species.

Where do you search for bats?

Bats use a variety of habitat types. When selecting sites to survey for bats, scientists often choose potential travel corridors, such as wooded streams, trails, and maintained rights-of-way. Rivers, streams, ponds, and lakes are also good places to search for bats because many bat species hunt for insects over water and almost all need to drink daily. Some bats use caves or other natural cavities such as rock outcrops with crevices, cliff faces, or even exfoliating bark on trees to roost, hibernate, and raise their young.

Bats can even be found in buildings. Agricultural buildings (e.g. farmhouses, barns, and outbuildings) of traditional wood, brick, or stone construction and/or with exposed wooden beams, and buildings and structures with slate roofs, stone walls, hanging slates, hanging tiles or weather boarding, are attractive to bats. This is especially true when these buildings are located near woods and/or water. Bats are also found in structures such as tunnels, mines, cellars, air raid shelters, bridge structures, and aqueducts. You just never know where you might find a bat!

Get Ready – Set Up Stations

1. Set up stations for each bat species to be measured.

2. Use the table, "Lengths and Weights - Bat Measurement Stations," to cut toothpicks to the correct length and to fill lunch bags with the correct weight. If you have bat models, place them at each station.

Each station needs:

- Gloves
- Toothpick cut to proper length (measure length of toothpick in millimeters)
- Bag with paper clips/beans/sand (weigh bag contents in grams) or bat model
- Clue card for one bat species
- Metric Ruler and metric scale

Get Set -Background Activities

1. Provide students with copies of the Student Inquiry Sheet.

2. Pose the questions on the sheet to students and ask them to design a data collection protocol for bat species identification through answering these questions or other questions they might develop.

3. Explain how bat biologists collect data on individual bats using the PowerPoint presentation, "Working the Night Shift –Biometric Clues." You could give students copies of the PowerPoint note pages and/or copies of the Background Information.

Go! - Measurement and Identification Activity

1. Give the students the following handouts and have them move to the stations:

- Student Instruction Sheet
- Bat Survey Data Form (for recording measurements and observations)
- Dichotomous Key for "Working the Night Shift - Western U.S. Bat Species"
- Optional – PowerPoint Notes Page from presentation to take notes on or write down follow-up questions

2. At the stations have the students work through the instructions on the Student Instruction Sheet.

3. After students have identified all of their bat species, provide them with copies of the table Western U.S. Bat Species: Identifying Features. Have the students verify their identifications are correct.

Go Even Further – Additional Activities

Here are a few additional activities that you can do with the students. These activities will build on how scientists collect data to study bats.

Please see "Further Reading Resources" for links to these resources.

- Read aloud one or more paragraphs of "An interview with Arizona-Sonora Desert Museum Bat Biologist – Karen Krebbs"
- Watch "The Battle for Bats: Surviving White-Nose Syndrome" (14 minutes). Ask students to list at least five ways bat biologists collect data.
- See scientists measuring bats, watch the interview with John Whitaker in "Cave: Life beneath the Forest" (4 minutes).
- Remind your students that now bat biologists ALWAYS wear gloves when handling bats.

1. Provide students with copies of the Student Evaluation Sheet.

2. Allow the students discussion time on how their data collection process related to the scientists in the films. Also allow for the students to discuss what can be learned by collecting bat data and how that data can be used. For example, what management actions might need to be implemented on the national forest to help protect bats?

Reflect – Evaluation

1. Accurately measure forearm lengths and bat weights

2. Record all data completely.

3. Correctly navigate the dichotomous key.

4. Correctly identify bat species and include supporting evidence.

5. Correctly answer questions about bat data collection. (Refer to "Teacher Answer Page" for general answers).

Extension - Install a Bat House

Installing a backyard bat house is a great way to provide a home for bats and to collect real-world data on a bat population. Bat houses are especially important in areas where there are few natural roosting sites such as large trees or caves. There are a variety of designs of bat houses and you can either make your own or purchase one. Consider placing a bat house in your community or encourage students to install one in their own backyard. One thing is for sure; your bat-tenants will pay you back with some wonderful benefits.

Bats are amazing animals that are vital to the health of our environment and economy eating tons of insects nightly. In temperate latitudes, like the United States, the bat species that are most likely to occupy a backyard bat house are insectivores that eat agricultural pests and some of the nasty bugs that harass outdoor gatherings (a.k.a. mosquitoes).

Your students will enjoy learning more about bats as they watch them come and go from the home you provided. And homes are often in short supply for bats. Their populations are declining around the world, often because of disappearing habitat.

Bats need time to find and explore new homes, so it may take a few years before your bat house has residents. Once they arrive, your students can start a monitoring program to count bats. The Wisconsin Department of Natural Resources has great information about their program and this could easily be modified for your home or classroom.

Consider building your bat boxes out of materials that are repurposed from other uses. For example, the Organization for Bat Conservation has been helping scouts build bat boxes out of used wood pallets. Can you think of other materials that could be used to build bat boxes? What about no longer needed wood furniture?

Just remember, if you use scrap wood that has been pressure-treated, it can only be used if you paint or stain over it. Pressure-treated wood contains chemicals that may be toxic to bats.

Suggested Resources:

Bat Conservation International - Artificial roosts
http://www.batcon.org/index.php/resources/for-specific-issues/artificial-roosts

Bat Conservation International – Install a bat house
http://www.batcon.org/index.php/resources/getting-involved/install-a-bat-house?highlight=WyJiYXQiLCJob3VzZSIsImJhdCBob3VzZSJd

Organization of Bat Conservation – Why bat houses are important
http://www.batconservation.org/bat-houses

Wisconsin Department of Natural Resources – Build a bat house
http://dnr.wi.gov/topic/wildlifehabitat/bathouse.html

Wisconsin Bat Program –Monitoring Program
http://wiatri.net/Inventory/Bats/

Further Reading and Resources – Discover More

About Bat Biologists:

An interview with Arizona-Sonora Desert Museum Bat Biologist – Karen Krebbs
www.desertmuseum.org/kids/bats/bat_biologist.php

An interview with John Whitaker in “Cave: Life Beneath the Forest” at
www.cavebiota.com/media/whitaker1.wmv

Discovery Channel. Dirty Jobs: Bat Biologist
www.discovery.com/tv-shows/dirty-jobs/videos/bat-biologist.htm

About Bats:

Bats in Your State - Species Profiles -
http://www.batcon.org/index.php/resources/media-education/species-profiles.

Hanging Around with Bats -
http://www.tpwd.state.tx.us/learning/resources/keepitexaswild/bats/

About White-Nose Syndrome:

Battle for Bats: Surviving White-nose Syndrome - http://vimeo.com/76705033

National White-Nose Syndrome (WNS) Website –
http://whitenosesyndrome.org/

Lengths and Weights - Bat Measurement Stations

Bat Species	Right Forearm Length* (toothpick length in millimeters)	Body Mass* (paperclips/beans/sand in grams)
Big brown bat *Eptesicus fuscus*	44 – 48 47	13 – 25 17
Townsend's big-eared bat *Corynorhinus townsendii*	40 – 45 42	5 – 20 8
Brazilian free-tailed bat *Tadarida braziliensis*	36 – 46 42	10 - 15 11
Canyon bat *Parastrellus hesperus*	29 – 31 30	3 – 6 4
Lesser long-nosed bat *Leptonycteris yerbabuenae*	46 – 57 47	18 – 30 28
Pallid bat *Antrozous pallidus*	50 – 56 55	17 – 28 28
California leaf-nosed bat *Macrotus californicus*	48 – 54 47	12 – 20 12

*** We have provided examples for these measurements in case you wish to make your own bat models. These numbers will maximize the number of similar sizes that you will need to cut out. You can use any number within the range listed.**

Teacher Answer Page

1. What kinds of data do bat biologists collect? How do they collect the data?

- Time
- Temperature
- Sex
- Condition of Wing
- Date
- Weight (in grams)
- Fur color and length
- Length measurements (ear, forearm, toe hair length, tragus, etc.)
- Location of Survey
- Age (juvenile or adult)
- Presence of Calcar
- Reproductive Condition

2. Why do bat biologists need biometric data from individual bats? Why do they make detailed records of the data?

- To identify bat species
- To quantify bat's health
- To track the health of bats over time – Are there changes in wing damage or weights?
- To determine a range of sizes for particular bat species
- To determine sex ratios and reproductive condition/success

3. Why do bat biologists need several kinds of information (biometric measurements, physical characteristics observations, behavioral observations) to correctly identify bat species?

Some bats have very similar appearances and even the length of their forearm and weight may be the same. Bat biologists need to look at a variety of information to correctly identify individual bat species. For example, a keeled calcar is one of the key diagnostic features that helps distinguish the Indiana bat from the little brown bat. These species are often very confusing for people just learning to identify bats.

4. If bat biologists had good baseline data, what changes in the data would they observe after White-Nose Syndrome has infected bats in an area?

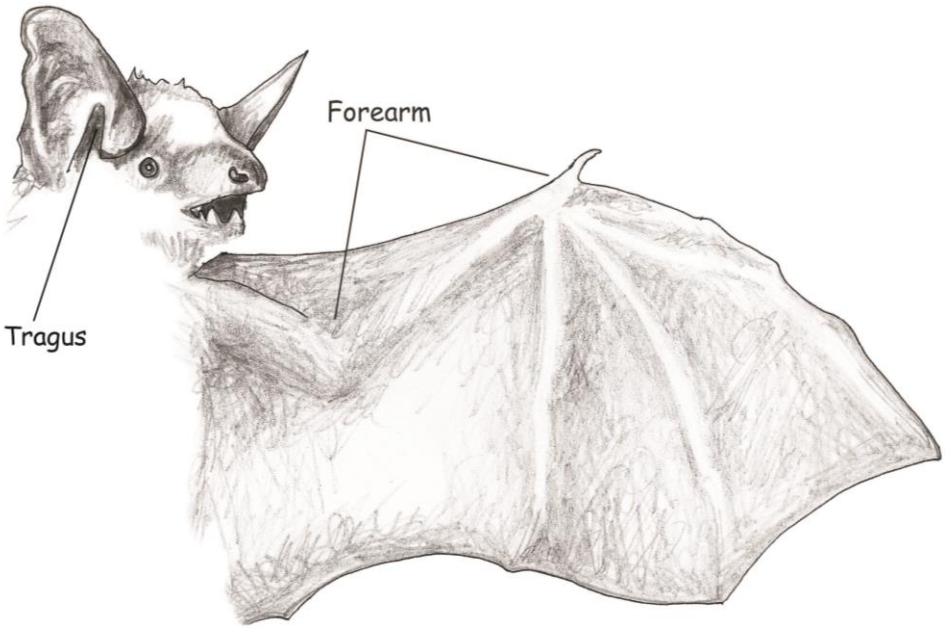
- Fewer bats
- Some species may be affected more by WNS than other species
- Lower body weights
- Bats may not be reproducing as a result of poor health or a lack of mates
- More wing lesions

Bat Clue Cards:

Bat 1 is the big brown bat
Bat 2 is Townsend's big-eared bat
Bat 3 is the Brazilian free-tailed bat
Bat 4 is the canyon bat
Bat 5 is the lesser long-nosed bat
Bat 6 is the pallid bat
Bat 7 is the California leaf-nosed bat

Calcar – a projection of cartilage that extends from the ankle of a bat along the edge of the tail membrane towards the tail; provides support during aerial turns.

Forearm - the part of a mammal's arm extending from the wrist to the elbow; in bats, measurements of its length are often used to identify one species from another.



Muzzle – the nose and mouth of an animal. When WNS is present on a bat, it is often seen on the muzzle.

Tragus – a tiny fingerlike projection of skin-covered cartilage in front of a bat's ear.

Keeled Calcar – a well-defined spur made of cartilage that extends from the ankle towards the tail.

A. Calcar Not Keeled B. Calcar Keeled

Tail Membrane – the area of skin which joins the legs and/or tail of a bat. The membrane may attach at the ankle or at the toe. This can be important for species identification.

Variation for Older Students:
Bat biologists also record information on the sex of each bat collected and their reproductive condition (e.g. are females lactating). Ask students why this information is important and what management strategies might be developed from this information.

- A skewed sex ratio may indicate that one species is migrating earlier or later than the other (depending on the time of year).
- If only females or females and young are captured during surveys, you may have a maternity colony nearby - something worthy of finding and protecting.
- A main focus now is to determine if White-Nose Syndrome is having an impact on sex ratios and reproduction rate. This is an important issue because bats have such a low reproductive rate. Most bats in North America only have one pup a year. Think about how long it would take to rebuild a population that was reduced by 90% or more!

PowerPoint Narrative

How do bat biologists identify bat species?
How do you think bat biologists can determine a bat's species? If you were going to collect data on a bat, what information would you need to help you determine a bat's species? What data would you collect? How would you collect the data? Where would you go to collect your data? A river? A forest? Your backyard?

One of the ways bat biologists study bats is by catching them, collecting biometric data (measuring right forearm lengths, weighing bats, looking at the color of fur, etc.), making observations, and using that information to identify species.

Where do bat biologists find bats?
Bats live in a wide variety of habitats. In the western United States, bat biologists look for bats near rivers and lakes where bats are hunting for insects or grabbing a drink of water. The top photo shows mist nets strung between two aluminum poles. Mist nets are usually made of nylon mesh suspended between two poles, resembling an oversized volleyball net. When properly set up, the nets are virtually invisible. You can't see the net and neither can the bats! Bats can also be found in forests and caves.

How do bat biologist catch bats?
Bat biologists catch bats in mist nets and harp traps. Harp traps are a metal frame strung with vertical monofilament line (like fishing line) with a bag at the bottom. Bats drop down to the bottom of the trap and are easily removed by biologists.

If bats are roosting in a cave, biologists can also just gently take them off the walls or ceiling of the cave, or they may just make observations of the bats. Sometimes, biologists even count the number of bats by using grids. Because bat biologists usually work at night or in caves, they need special clothing and lights.

How do bat biologists handle bats?
Bats are small and have delicate wings. To minimize damaging bat wings, biologists have special training and experience. Bat biologists always wear gloves when handling bats to avoid transmitting diseases to the bats and to avoid being bitten by bats. You should NEVER handle wild animals unless you have proper equipment, training, and vaccinations.

Why are there pictures of lunch bags on this page? Biologists actually store bats in lunch bags to keep them calm while transporting bats short distances and when there are lots of bats to identify and measure. Lunch bags are inexpensive.

Biometric measurements - right forearm
It's relatively easy for a trained biologist to hold a bat and extend the bat's wing in order to measure the right forearm. The forearm of a bat is the small bone at the top of the wing membrane, between the elbow and the thumb. Using a caliper or ruler, a biologist measures the length of the bat's right forearm, recording the data in millimeters.

Bat wings are one of the most remarkable features of a bat. A bat's wing is actually a modified hand and the wing bones are elongated fingers. This elongation of the bones is required to support the wing membrane. Compare the bones of the wing to the fingers on a human hand. Also point out the thumb. The thumb has a small claw, which aids the bat in crawling around on rough surfaces.

Biometric measurements - weighing bats
A bat can be weighed while it's still in a lunch bag or the bat can be transferred to a plastic container. When you do this step, remember that you need to tare the weight using an empty bag or container first. Bat biologists usually use a pan scale or a spring scale and record the bat's weight in grams.

Biometric clues - examining bat wings
Bat wings hold clues about a bat's health and can sometimes show if the bat has been infected with the fungus that causes White-Nose Syndrome. Bat wings are gently extended and held over a light box for careful examination. Do you see the difference between the healthy bat wing and the damaged bat wing? Sometimes bat biologists even use ultraviolet light to check for White-Nose Syndrome lesions on bat wings. What do you think would happen if a bat's wing was badly damaged?

The membrane of a bat's wing is living tissue similar to the tiny flaps of skin joining the bases of our human fingers. Bats have a much larger membrane of skin that joins their long fingers from the bases to the tips. A bat's fingers cannot flex independently, but the muscles in the arm can open up the hand. Do you think a bat's wing can heal over time?

Yes, sometimes bats get tears in their wings. A small tear in the wing up to about an inch doesn't cause the bat much trouble in flight. Since the bat's wing is living tissue, it can heal itself. But, if the wing is torn too badly, and the bat can't fly, then the bat would not be able to feed itself.

Observing physical and behavioral characteristics
You might spend a lot of time with your pet cat or dog. You can recognize them instantly! But what if a similar looking animal appeared on your front porch? Would you know if it was really your pet?

Bat biologists also spend a lot of time looking at bats. Sometimes they can instantly recognize a bat's species. Often it's more difficult. Scientists look at many physical characteristics to help identify bats. These include: age (juvenile or adult), sex, overall size, fur color, fur length, ear size, tragus size, tail membrane, calcar, and toe hair length. Explain some of the parts of the bat that students might not be familiar with including the tragus, calcar, and tail membrane.

A keeled calcar is a well-defined spur made of cartilage that extends from the ankle towards the tail. It provides support during aerial turns. The tragus is a tiny fingerlike projection of skin-covered cartilage in front of a bat's ear (after the activity, encourage students to look into the purpose of the tragus). The tail membrane is the skin which joins the legs and/or tail of a bat. The membrane may attach at the ankle or at the toe. All of these characteristic can be important for species identification.

Recording data
Now the biologists have all of this information. What do they do with it? First, they need to record it so they can refer to it later. Accurate records are really important for bat surveys. For example, bat biologists might want to compare bats' weight and health to previous years.

Who am I? Collecting your data
You, the bat biologist, will be recording the data that you observe on your Bat Survey Data Form including:

Time	Location	Weather
Weight	Right forearm length	Other Physical characteristics
Date	Behavioral characteristics	

You will take this data and use the dichotomous key to be sure to list the evidence that supports your identification of the bat species.

Student Inquiry Sheet

Working the Night Shift **Bat biologist (your) name**_____

First Things, First – Before Doing the Activity

You are a bat biologist. You have been asked to catch bats at a National Forest and identify the species of bats that are present.

1. How do you think bat biologists can determine a bat's species?

2. If you were going to collect data on a bat, what information would you need to help you determine a bat's species? What data would you collect? How would you collect the data?

3. What time of year would you collect the data? Where would you go to collect the most data on bats? Why?

Student Instruction Sheet

Start Your Bat Survey- Measurement and Identification Activity

1. Put on gloves to do these activities. Bat biologists now always work while wearing gloves. You might find that it's a little bit harder to do detailed work when you are wearing gloves. Why do you think it is important to wear gloves?

2. Weigh an empty lunch bag. Remember, you need to tare the weight at each station or you can subtract the weight of a bag from every bat weight measurement.

3. Make weight measurements of all bat models/lunch bags and measure toothpicks which represent the bat's right forearm. Be sure to record your data and information from the clue card on your Bat Survey Data Form. Include information about the bat's physical and behavioral characteristics.

4. Use your recorded data and the dichotomous key to determine the bat's species. Are you confident that you have made the correct identification? Be sure to write down any evidence that supports your identification of the bat species. Were any species similar? Do you think you could collect this data at night?

5. Use the Western U.S. Bat Species: Identifying Features to verify your findings.

Student Evaluation Sheet

What Did You Learn?

1. What kinds of data do bat biologists collect? How do they collect the data?

2. How did your data collection design match up to the activities performed in this activity? Did you identify the same types of information to collect to help you determine a bat's species?

3. Why do bat biologists need biometric data from individual bats? Why do they make detailed records of the data?

4. Why do bat biologists need several kinds of information (biometric measurements, physical characteristics observations, and behavioral observations) to correctly identify bat species?

5. If bat biologists had good baseline data about a bat population, what changes in the data would they observe after White-Nose Syndrome has infected bats in an area?

6. Do you think it is important to help bats?

7. How could you help bats around your school or home?

Bat Survey Data Form

Bat Biologist's Name: _____ Survey Location:_____

Date of Observation: _____ Time of Observation: _____ Weather Conditions: _____

Station Number	Right Forearm Length	Weight of Bat	Physical Characteristics	Behavioral Characteristics	Species Name	Evidence that Supports Your Identification of the Bat Species
1.						
2.						
3.						
4.						

Bat Survey Data Form

Bat Biologist's Name: _____ Survey Location:_____

Date of Observation: _____ Time of Observation: _____ Weather Conditions: _____

Station Number	Right Forearm Length	Weight of Bat	Physical Characteristics	Behavioral Characteristics	Species Name	Evidence that Supports Your Identification of the Bat Species
5.						
6.						
7.						

Other Observations:_____

Western U.S. Bat Species: Identifying Features

Bat species	Right forearm length (range in mm)	Body mass (range in grams)	Physical characteristics	Behavioral characteristics
Big brown bat *Eptesicus fuscus*	44 – 48	13 – 25	Distinctive brown fur Robust jaws and teeth Rounded (blunt) tragus	Often found living in buildings Use many habitats
Townsend's big-eared bat *Corynorhinus townsendii*	40 - 45	5 - 20	Large ears, up to 40mm in length Two glandular lumps on muzzle	Roost singly or in groups in caves and mines, considered a moth specialist Curls up its long ears so that they look like ram horns
Brazilian free-tailed bat *Tadarida braziliensis*	36 - 46	10 - 15	Large wrinkled lips Tail extends well beyond the tail membrane	Large maternity colonies of up to millions of bats, usually migratory
Canyon bat *Parastrellus hesperus*	29 - 31	3 - 6	distinctive black face mask Club shaped tragus	Smallest bat in the U.S. Slow, erratic, butterfly-like flight
Lesser long-nosed bat *Leptonycteris yerbabuenae*	46 - 57	18 - 30	Elongated muzzle Small, triangular nose leaf Tail is minute and appears to be missing	Does not hibernate - migrates between Central America and southern U.S. Nectivorous (feeds on nectar, fruit, pollen)
Pallid bat *Antrozous pallidus*	50 – 56	17 - 28	Large ears Horseshoe-shaped ridge above nostrils Wooly fur is creamy or yellowish	Eats a variety of insects Large ears allow the bat to detect the sound of its prey's footsteps.
California leaf-nosed bat *Macrotus californicus*	48 – 54	12 - 20	Large ears are united Nose leaf is erect, and arrowhead shaped Tails is present and extends slightly beyond interfemoral membrane	Gregarious; colonies of dozens to hundreds can be common, always in desert caves and abandoned mines

DICHOTOMOUS KEY

Working the Night Shift - Western U.S. Bat Species

1. A. Nose leaf absent	Go to 3
B. Nose leaf present	Go to 2
2. A. Tail absent or minute, snout elongated, Ears less than 25mm	***Leptonycteris yerbuenae***
B. Tail present, snout not elongated, Ears greater than or equal to 25 mm	***Macrotus californicus***
3. A. Ears <25 mm from notch to tip	Go to 5
B. Ears >25 mm from notch to tip	Go to 4
4. A. Ears 33-39 mm with large lumps on either side of muzzle	***Corynorhinus townsendii***
B. Ears 25-33 mm, horseshoe shaped ridge above nostrils	***Antrozous pallidus***
5. A. Tail extends well beyond tail membrane	***Tadarida brasiliensis***
B. Tail doesn't extends past tail membrane	Got to 6
6. A. Right forearm greater than 42 mm, rounded, blunt tragus	***Eptesicus fuscus***
B. Right forearm 27-33 mm, tragus short, blunt, and club-shaped	***Parastrellus hesperus***

Clue Cards - Who Am I?

Photo by U.S. Fish and Wildlife Service

Bat 1 - Physical Characteristics

Ear Length: 16 – 20 millimeters (from notch to tip)

Nose Leaf: absent

Fur Color: tan to dark, chocolate brown

Tail: does not extend beyond tail membrane

Tragus: broad with rounded tip

Bat 1 - Behavioral Characteristics

- I use many habitats from lowland deserts to timberline meadows.
- I am often found living in buildings.
- I'm very beneficial – eating significant crop and forest pests including ground beetles, scarab beetles, cucumber beetles, snout beetles and stink bugs, as well as many species of moths and leafhoppers.
- I hibernate in caves.

© Merlin D. Tuttle, Bat Conservation International, www.batcon.org

Bat 2 - Physical Characteristics

Ear Length: 33 – 39 millimeters (from notch to tip) with lumps on either side of muzzle

Nose Leaf: absent

Fur Color: varies from pale brown to blackish-grey; underfur is paler

Bat 2 - Behavioral Characteristics

- I am considered a moth specialist.
- I roost singly or in groups in caves and mines.
- When roosting or hibernating, I curl up my long ears so they look like ram horns.
- My populations, especially in nursery and hibernaculum, are highly susceptible to disturbance and have been reported to be declining.

Photo by University of New Mexico

Bat 3 - Physical Characteristics

Ear Length: 8-15 millimeters (from notch to tip)

Nose Leaf: absent

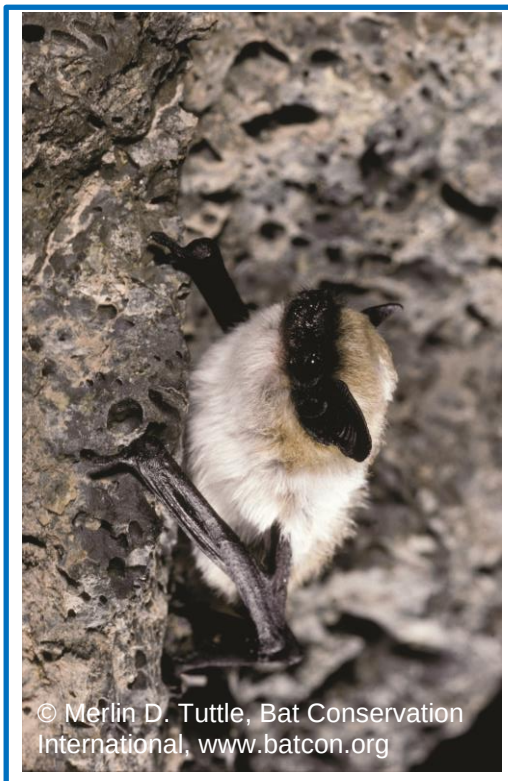
Fur Color: short, dark brown fur that is velvety in texture

Tail: extends well beyond the tail membrane

Other: lips are furrowed by vertical grooves and look wrinkly

Bat 3 - Behavioral Characteristics

- I am a social and highly gregarious bat, even in flight.
- I form large maternity colonies of up to several million bats, especially in natural caves.
- Because of our large numbers, we create great quantities of guano on cave floors, which creates nourishment for other animals that live in caves.



© Merlin D. Tuttle, Bat Conservation International, www.batcon.org

Bat 4 - Physical Characteristics

Ear Length: 10 - 12 millimeters (from notch to tip)

Nose Leaf: absent

Calcar: keeled

Fur Color: Yellow to light grey to brown fur

Tail: does not extend beyond tail membrane

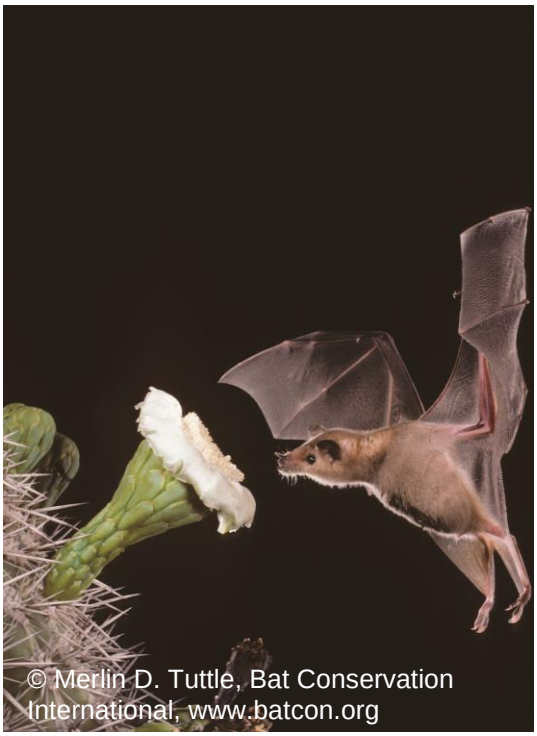
Tragus: club-shaped

Other: I have a distinctive black face mask.

Bat 4 - Behavioral Characteristics

- I am a bat of the desert living in arid canyons or dry shrub lands, near water.
- I enjoy eating a variety of insects including small moths, beetles, mosquitoes, and flies.
- I have slow, erratic, butterfly-like flight.
- I am the smallest bat in the United States.

Clue Cards - Who Am I?



Bat 5 - Physical Characteristics

Ear Length: 16-21 millimeters (from notch to tip)

Nose Leaf: present and triangular in shape

Fur Color: yellow-brown above

Tail: three caudal vertebrae but no externally visible tail

Other: snout elongated

Bat 5 - Behavioral Characteristics

- I roost during the day in large colonies of up to several thousand individuals in caves or abandoned mines, dispersing at night to feed.
- I eat nectar, pollen, and fruit and feed exclusively on night-blooming cacti.
- I am often covered with pollen that I ingest in the process of grooming my fur with my feet and then licking my claws to remove the collected pollen.
- I do not hibernate as I cannot withstand prolonged exposure to cold - migrate to Central America.

© Merlin D. Tuttle, Bat Conservation International, www.batcon.org

Bat 6 - Physical Characteristics

Ear Length: 25-33 millimeters (from notch to tip)

Nose Leaf: absent

Fur Color: yellowish brown to cream

Other: horseshoe-shaped ridge above nostrils secretes a distinct skunk-like scent

Bat 6 - Behavioral Characteristics

- I live in low elevation rocky arid deserts and canyonlands, shrub-steppe grasslands, karst formations, and higher elevation coniferous forests.
- I am a generalist eating beetles, centipedes, cicadas, crickets, grasshoppers, katydids, moths, praying mantids, scorpions, and termites.
- Because I have such large ears, I can detect the sound of my prey's footsteps on the ground. I can even land on the ground to capture my prey.

© Merlin D. Tuttle, Bat Conservation International, www.batcon.org

Bat 7 - Physical Characteristics

Ear Length: greater than 25 millimeters (from notch to tip)

Nose Leaf: present, erect, and arrowhead shaped

Fur Color: Grayish to dark brown

Tail: present and extends slightly beyond the tip of the interfemoral membrane

Other: snout not elongated

Bat 7 - Behavioral Characteristics

- My preferred habitats are caves, mines, and rock shelters, mostly in Sonoran desert scrub.
- I do not hibernate or migrate.
- I feed primarily on moths and immobile diurnal insects such as katydids which I locate by vision, even at low ambient light levels.
- I often hang from one foot, using the other to scratch or groom myself.

Variation for Younger Students

Consider only using three bat species for this activity that can easily be distinguished from each other. The big-brown, pallid, and canyon can be identified based solely on weight and the length of the forearm.

Have younger students take these measurements and record their data. They can use the "Western U.S. Bat Species: Identifying Features" table to identify the species. Students can still collect data and identify a bat without going through a dichotomous key!

Answer to clue cards can be found on Teacher Answer Page.

Variation for Older Students

If available, borrow old mist nets from a local Department of Natural Resources, Forest Service, or Fish and Wildlife Service office. You can place the nets up in a darkened room such as a gymnasium. Have students put on gloves and headlamps. They will remove the bats from the nets, take measurements, and record the data in the dark.

Bat biologists also record information on the sex of each bat collected and their reproductive condition. Ask students why this information is important and what management strategies might be developed from this information?

Answer to clue cards can be found on Teacher Answer Page.

Curriculum/Standards Connections

Science Standards
Virginia science standards are listed here as examples. You can find citations for your state's standards by searching for the key words, "dichotomous key," "species," "binomial nomenclature," and "classify or classification."

Virginia Middle School Science – Life Science Standards
LS.5 The student will investigate and understand how organisms can be classified. Key concepts include:

a) the distinguishing characteristics of kingdoms of organisms;
b) the distinguishing characteristics of major animal and plant phyla; and
c) the characteristics of the species.

Skills

- compare and contrast key features and activities between organisms.
- classify organisms based on physical features.

Virginia High School Science – Biology Standards
BIO.7 The student will investigate and understand bases for modern classification systems. Key concepts include:

a) structural similarities among organisms;

Knowledge

- Binomial nomenclature is a standard way of identifying a species with a scientific two-word name. The first word is the genus name and the second the species name.
- A species is defined as a group of organisms that has the ability to interbreed and produce fertile offspring.

Skills

- Construct and utilize dichotomous keys to classify groups of objects and organisms.
- Describe relationships based on homologous structures.

Next Generation Science Standards

Middle School Life Science (for worksheet question and for extension activity)
MS-LS2-4. Ecosystems: Interactions, Energy, and Dynamics: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)
RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4)
WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)