Chapter 17

Observational Investigation of Systematics, Physiology, and Behavior of Vertebrates in a Living Collection

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Introduction

Many colleges and universities are near major vertebrate collections in accredited zoological parks and aquariums. All institutions that are accredited by the Association of Zoos and Aquariums maintain an education department with information about their individual collection. Many of the larger zoos are engaged in research in the areas of conservation, animal behavior, genetics and reproduction of endangered species, and animal health and nutrition.

Using the zoo as a resource to teach vertebrate biology has a number of advantages. The vast majority of our Diversity of Life students at Incarnate Word College are non-science majors who take this course to satisfy their laboratory science requirement. Both majors and non-majors are enthusiastic about studying a living collection. These exercises are also very cost effective. Admission to some zoos is free, and most others offer a discount to school groups. The San Antonio Zoo offers college students unlimited visits to the zoo for $6.00 per semester. Since we spend four class periods at the zoo, the cost per student per lab is $1.50.

Some difficulties inevitably occur because living specimens are not always predictable. They may be asleep or in an area of the exhibit where they cannot be easily observed. The exercise must be adjusted to reflect the specimens that are currently on exhibit. Weather and transportation may also present problems, but the advantages of observing and interpreting living vertebrate specimens minimizes these problems. These activities can be conducted during three, 2-hour visits, or one day-long visit.

Observational investigations of living specimens are practical alternatives to observation of dissection of preserved specimens. Student interest and involvement is consistently high and retention of basic principles is enhanced. A good general reference is Richard Estes' *The Behavior Guide to African Mammals: Including Hoofed Mammals, Carnivores, Primates* (University of California Press, Berkeley, 611 pages, 1991).

Student Outline
Objectives

1. To observe and identify distinguishing characteristics of the various classes of vertebrates.
2. To relate and infer structures to physiological function in vertebrates.
3. To correlate physiological adaptations to habitat.
4. To observe and interpret behavioral characteristics of a group of animals.

Exercise 1:
Systematics of Subphylum Vertebrata

Purpose: To observe and identify distinguishing characteristics of representatives of Subphylum Vertebrata; to observe and identify distinguishing characteristics of representatives of Class Aves and Class Mammalia.

Procedure: Locate the designated number of examples of each of the following classes of vertebrates. Use the observational keys provided in Table 17.1 for vertebrate classes, Table 17.2 for bird orders, and Table 17.3 for mammalian orders. Provide the common and scientific name for each animal in order to complete Table 17.4.

Table 17.1. Observable characteristics of classes in the Subphylum Vertebrata.

Class	Characteristics
Elasmobranchiomorphi (cartilaginous fish)	Fins, asymmetrical caudal fin (in sharks) spiracles, visible gill slits
Osteichtheys (bony fish)	Fins, scales usually visible, gills covered by an operculum
Amphibia	Smooth, moist skin. Gills, and lungs in most forms at some stage of life.
Reptilia	Dry, scaly skin. Substances that keep the skin moist are not produced. Air breathing.
Aves	Feathers
Mammalia	Hair or fur

Table 17.2. Observable characteristics of bird orders.

Order	Characteristics
Anseriformes (waterfowl)	Full web between three front toes, long necks, pointed wings, short legs, flat bills. Swans, geese, ducks.
Falconiformes (diurnal birds of prey, raptors)	Heavy, sharp, hooked bill. Toes with strong curved talons. Fleshy sere (cover) covers base of upper bill and nostrils. Vultures, hawks, eagles, and falcons.
Galliformes (chicken-like land birds)	Short, heavy, down-curved bill. Short, rounded wings. Capable runners. Seldom fly more than a few feet. Jungle fowl, pheasants, turkeys, currasows, quail, grouse.
Ciconiiformes (herons and allies)	Wading birds with long necks, legs, and bills. Variable foot and bill structure. Wings broad and rounded, tails are short. Herons can be distinguished from cranes by their characteristic "s" shaped neck when at rest or in flight. Herons, ibis, spoonbills, flamingos, storks.
Gruiformes (cranes, rails and allies)	Wading birds with long legs. Feet may be incompletely webbed. Cranes are tall and carry their necks in an extended position. Other members of this order are variable in size and bill shape. Cranes, sunbittern, rails, coots, gallinules.
Charadriiformes (shorebirds)	Diverse group of wading or swimming birds. Long pointed wings and long legs or webbed feet. Mostly white, gray, or brown. Gulls, oystercatchers, plovers, thick-knees, stilts, jacanas, avocets, curlews.
Strigiformes (owls)	Large-headed, short-necked, mostly nocturnal birds of prey. Narrow, sickle-shaped, hooked bill. Large eyes are fixed in their sockets so entire head moves as the owl shifts its gaze. Usually perches with two toes forward, two toes back.
Piciformes (woodpeckers and allies)	Varied order of arboreal nesting birds. Foot is zygodactyl, with second and third toes directed forward, first and fourth directed back. Use sharply pointed bill for chipping of digging into tree trunks. Woodpeckers, toucans, toucanets, barbets.
Psittaciformes (parrots)	Brightly colored, noisy, tropical and semitropical birds with a sharp, thick hooked bill. Two toes forward, two toes back (zygodactyl). Uses its foot to bring food to mouth which is unusual in birds. Parrots, cockatoos, conures, macaws, lories.
Coraciiformes (kingfishers)	Large-headed, short-tailed with long straight sharp beak. Dive for fish. Two outermost toes joined for most of their length (syndactyl). Kingfishers, motmots.

Table 17.3. Observable characteristics of mammalian orders.

Class	Characteristics
Monotremata (platypus and echidnas)	Primitive egg-laying mammals. Skull and lower jaw modified to form a bill-like structure. Possess hair, mammary glands without nipples, lack teeth.
Marsupialia (four groups including opossums, kangaroos, koalas, wombats)	Pouched mammals. Young born in a premature condition and carried by the female in a pouch.
Chiroptera (bats)	True flying mammals of small to medium size. Bone of palms and fingers elongated and covered with a membrane that extends to the ankle.
Primates (prosimians, Old World monkeys, New World Monkeys, gibbons, apes)	Small to large mammals with highly developed cerebral hemispheres. Limbs with ball and socket articulation, allowing for great motility. Opposable thumbs or great toes. Nails replace claws on some or all of digits.
Edentata (New World anteaters, tree sloths, armadillos)	Incisors and canines always lacking; all teeth lacking in some species. Front claws greatly enlarged for clawing or hanging from trees.
Rodentia (squirrels, gophers, rats, mice, beavers, agoutis, hutias, pacaranas, porcupine, capybaras)	Very small to medium-sized mammals with two upper and two lower chisel-like incisors adapted for gnawing
Carnivora (dogs, cats, bears, skunks, raccoons, hyenas)	Small to very large-sized predators. Canines large. Carnassial teeth modified for cutting and shearing meat. Eyes directed forward.
Pinnipedia (seals, sea lions, walrus)	Aquatic predators that breed on land. Limbs modified into flippers.
Proboscidia (elephants)	Very large, very long trunk. Massive head. Prominent tusks. Legs columnar. African and Asian species.
Perissodactyla (horses, rhinos, tapirs)	Large to very large. Odd-numbered toes, hoofed mammals. Main axis of foot through third digit.
Artiodactyla (swine, peccaries, hippos, camels, llamas, deer, giraffe, cattle, antelope)	Small to very large. Even-numbered toes, hoofed mammals. Main axis of foot between toes three and four.

Table 17.4. Identification of 50 animals that you observed (provide common and scientific names).

Vertebrate class	Common and scientific names
Elamobranchiomorphi (cartilaginous fish)	1.
Osteichtheys (bony fish)	
Lobed-fin fish	2.
Spiny-finned fish	3.
	4.
	5.
	6.
	7.
Amphibia	8.
	9.
	10.
	11.
Reptilia	12.
	13.
	14.
	15.
	16.

Orders of birds	Common and scientific names
Anseriformes	17.
Falconiformes	18.
Galliformes	19.

Ciconiiformes	20.
Gruiformes	21.
Charadriiformes	22.
Strigiformes	23.
Pisciformes	24.
Psittaciformes	25.
Coraciiformes	26.

Orders of mammals	Common and scientific names
Monotremata	27.
Marsupialia	28.
	29.
Chiroptera	30.
Primates	
Old World	31.
	32.
New World	33.
	34.
Edentata	35.
Rodentia	36.
	37.
	38.
Carnivora	39.
	40.
	41.
	42.
Pinnipedia	43.

Proboscidia	44.
Perissodactyla	45.
	46.
Artiodactyla	47.
	48.
	49.
	50.

Exercise 2: Vertebrate Physiology (Digestion, Circulation, Water Balance, and Elimination)

Purpose: To observe structures in vertebrates that have a physiological function.

Procedures:
Bird beak structure and diet: Observe birds in designated bird areas. Feeding behavior in birds is related to beak structure. Use Figure 17.1 to complete Table 17.5. If you saw a bird flying overhead with a bill shaped like number one in Figure 17.1, what could you deduce about that bird's diet?

Table 17.5. Beak structure and diet.

Diet	Common and scientific name	Bill shape
Seed eater (granivorous)	1.	
	2.	
Fruit eater (frugivorous)	1.	
	2.	
Flesh eater (carnivorous)	1.	
	2.	
Fish eater (piscivorous)	1. 2.	
Insect eater (insectivorous)	1. 2.	

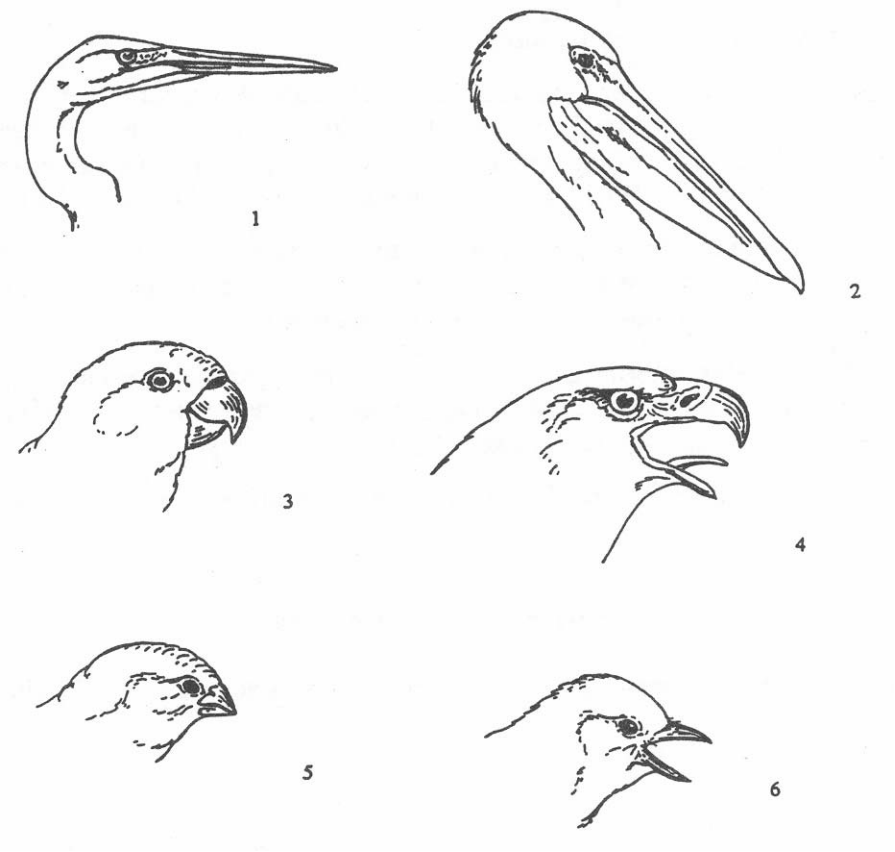

Figure 17.1. Types of bird beaks (illustration by Gloria Merlo, San Antonio Zoo).

Hoofed mammals (giraffe, rhinos, zebra, antelope, and camel):

1. Artiodactyla (even-toed ungulates) include the antelopes, deer, sheep, giraffes, hippos, and camels. These animals are herbivorous (plant eaters). Most members of this order are ruminants. These animals have multichambered stomachs and rechew their food to increase the surface area for bacterial action to break down the cellulose in the plant cell walls. The bacterial action takes place in the stomach rather than in the intestinal tract. Describe the movement of the jaw when these animals chew. Is this best for grinding or tearing food?
2. The ruminating stomach is a very efficient method of digestion for animals that have a diet of coarse vegetation. Observe the end waste products of digestion of an antelope, an elephant, and a zebra. Which has the most efficient digestive system? Are the elephant and zebra ruminants? How can you tell?
3. Observe the lip structure of the giraffe and the zebra. The giraffe has a narrow lip. This is the typical lip structure of animals that feed by browsing. Browsers pull leaves from woody plants. Grazers such as the zebra clip grass and usually have a wider lip structure than browsers. The black rhino and the white rhino are in the Order Perissodactyla (odd-toed hoofed mammals). Describe the lip structure of the black rhino and the white rhino. Are they grazers or browsers?

4. Describe how the elephant uses its truck in respiration, digestion, and water balance.

Physiological adaptations to different habitats:

1. Fat is stored by vertebrates in order to survive through periods of time when food or water are scarce. Some lizards, such as the shingle-backed skinks, store fat in their tails. Metabolism of fat produces energy and water. The camel's hump performs the same function for the camel as the enlarged tail of the desert dwelling skinks. What is the adaptive significance of the camel's hump?
2. Many bears live in climates that are very cold for at least part of the year. Do bears have large or small ears? Suggest an adaptive advantage of having ears this size. Is the ratio of surface area to body size large or small? Suggest an adaptive advantage for this.
3. Are the gills of bony fishes internal or external? The surface area of capillaries present in the gills is large. What process does this facilitate? Gas exchange requires a moist surface. Fish suffocate when they are out of water. Provide a reason for this.
4. What adaptations to aquatic life are shared by the hippo and the members of the crocodile order? (Look at eyes, nostrils, and ears.)

Exercise 3: Vertebrate Behavior

Purpose: To learn how researchers observe behavior and to understand the significance of behavior in primates.

Procedures:

Behavioral study: If the institution has a staff member who is engaged in a scientific study of animal behavior, the study may be presented to the class by a zoo employee. Answer the following questions about the behavioral study presented: (1) State the purpose of this study. (2) State the methods by which the data are obtained. (3) What is currently understood about behavior of the animals in the study group?

Primate behavior:

1. Observe a polygamous or harem group of primates which contains more than four adult animals for 30 minutes. Record and classify any type of behaviors you observe. Note any behavior that is not described in Table 17.6.
2. Observe a monogamous family group of primates, such as the marmosets or gibbons, for 30 minutes. Record and classify the behaviors you observe.
3. Compare the observation you have made for the primate families with multiple adults living together and the monogamous family group of primates.

Table 17.6. Guide to primate behavior.

Behavior	Examples
Facial expressions	*Threats*: Animal appears to yawn. The individual is showing off the large canine teeth. Staring is another form of threat. These may be combined. *Fear*: Grimace which looks almost like a smile with teeth clenched. An appeasing signal to reduce aggression. *Friendly*: Lip-smacking, teeth chattering, and play face, an open-mouth display with eyes partially closed and not staring.
Postures	*Submission*: Presenting the buttocks to another animal is an act of submission. The animal in the submissive posture is vulnerable to attack. This behavior prevents aggression. *Grooming*: Social grooming is a universal primate trait that reinforces pair bonds as well functioning in improving skin hygiene. Self-grooming or "displacement" is a form "saving face." *Dominance*: Walking with a "swagger," displacing another animal, surveillance or "watchdog" behavior all indicate that this is a dominant animal. *Threats*: Head-bobbing, false pursuit, and false flight. *Play invitation*: A lurching, "drunken" run, swinging, jumping, or somersault. Usually young animals and is combined with the "play face."
Calling	Some primates, notably the gibbons, use calls to reinforce family bonds. Female gibbon initiates the calls and is joined by the male in a duet.

Notes for the Instructor

Student responses to the exercise questions can be answered on the back of the handout page or in a separate notebook. We encourage our students to maintain an observation notebook, and they often take pictures of the various animals and include these and additional notes in their notebooks.

Instructors can escort their students through the zoo completing one exercise at a time. However, students tend to expect the instructor to answer their assigned questions with this format. We encourage our students to explore the zoo on their own, and meet us at designated areas if they have questions. In order to minimize students leaving early, we require an instructor signature on the lab exercise and/or notebook for the work to count toward the grade; we do not sign papers before the last 15 minutes of the lab period.

Exercise 1: Systematics of Subphylum Vertebrata

Each zoological collection will vary in representative animals, and thus numbers of each vertebrate class will also vary. It is suggested that you conduct your own tour first to complete this exercise. The educational department at most zoos will be very happy to assist you and will often provide you and/or your class with trained docents.

Exercise 2: Vertebrate Physiology

Bird beak structure and diet: Seed eaters (beak shape #5 in Figure 17.1): examples include finches and the pigeon family. Fruit eaters (#3): parrots and lorikeets. Flesh eaters (#4): eagles and hawks. Fish eaters (#1 and 2): the kingfisher and herons. Insect eaters (#6): mynas. Some beaks adapted for eating seeds can also be used for eating fruits, and some beaks adapted to eating fish can also be used for eating invertebrates.

Hoofed mammals: (1) The movement of the jaw of the Artiodactyla is best for grinding food. (2) The antelope has the most efficient (elephants have the least efficient) digestive system as evidenced by the small volume of solid waste and absence of undigested material in the feces. The inefficient digestive process of the elephant and zebra implies that they are not ruminants. (3) The black rhino has a pointy lip and thus is a browser. The white rhino lip is broad and flat and thus it is a grazer. (White does not refer to the color of the animal, but is a derivative of the German word for wide, referring to its lip shape.) (4) The elephant trunk is used for breathing, is an aid in gathering food, and can be used to draw in water for drinking.

Physiological adaptations to different habitats: (1) The camel's hump is an adaptation to survive shortages of water and food. (2) Bears have small ears, and this is an adaption to cold climates, as is a small surface area to body size since this reduces the area for heat loss. (3) The internal gills of fishes have a large surface area to facilitate gas exchange. Fish suffocate out of water because the membrane across which oxygen diffuses dries out, and oxygen cannot efficiently diffuse across a membrane unless it is dissolved in water. (4) The eyes, nostrils, and ears of hippos and crocodiles are positioned in line so that they remain above water while the rest of the head and the entire body can be submerged under water.

Exercise 3: Vertebrate Behavior

Behavioral study: Inquire about behavioral studies at the Education Department at your local zoo. This exercise is valuable for presenting the educational and research mission of zoological collections.

Primate behavior: The social organization of primates is complex. See Richard Estes' *The Behavior Guide to African Mammals: Including Hoofed Mammals, Carnivores, Primates* (University of California Press, Berkeley, 611 pages, 1991) for details. In general, most African primates are polygamous-like, but observing this social grouping may depend on how the primates are exhibited. Monogamous-like primates include marmosets, tamarins, and gibbons.