

3. FUNCTIONAL COMPARATIVE ANATOMY & PHYSIOLOGY OF BIRDS OF PREY AND DOMESTIC CHICKEN- Dr. Boniface M. Kavoi

Key issues to address:

1. Anatomy of the various organs/ organ systems of birds and how are adapted to function
2. How the anatomy of birds of prey differ from that of chicken
3. Key anatomical issues in veterinary forensics

Aves- Classification

Birds belong to the scientific class Aves. These are bipedal animals with feathers, wings, beaks, and scales on their legs and feet. They are endothermic (warm-blooded), breathe air, and lay eggs. Chicken fall in the order Galliformes. These are heavy-bodied ground-feeding birds that include chicken, turkey, grouse, New and Old World quail, ptarmigan, partridge, pheasant, and the Cracidae. They are arboreal or terrestrial animals; many prefer not to fly, but instead walk and run for locomotion.

Birds of prey belong to the order Falconiformes. These birds are characterized by strong bills that are hooked at the tip and sharp on the edges. Their feet have sharp, curved talons and an opposable hind toe. They have a keen vision. They are generally strong flyers. They eat other animals hence called birds of prey or raptors. They hunt during the day and thus called diurnal birds of prey. Owls (Order Strigiformes) are also birds of prey, but they are nocturnal (hunt at night).

Some important families:

1. Accipitridae: Include bald eagles, red-tailed hawks, bearded vultures
2. Cathartidae: Include white-headed vulture, black vulture, California and Andean condor
3. Falconidae: Include the American kestrel, peregrine falcon, crested caracara.

Distribution

Some species, like the osprey and peregrine falcon, are global. Others, like the Seychelles kestrel are restricted to certain regions (Seychelles islands). Old World vultures are found in the Eastern Hemisphere, including Europe, Asia, and Africa. New World vultures are found in the Western Hemisphere, specifically North and South America.

Habitat

Some species can exploit a variety of habitats while others are restricted to one type of habitat. Many species prefer forest habitats e.g. sharp shinned hawks - deciduous forests. Savannas (grasslands with scattered trees) also support a variety of species e.g. white-

headed vultures and bateleur eagles. Species found in desert habitats include lappetfaced vultures of Africa.

Migration

This is the seasonal movement between a breeding region and a nonbreeding region. Migration allows birds go to areas with abundant food supplies for raising young. The birds have an "internal calendar" to determine the correct time for migration. Majority of bird of prey species are not true migrators. Patterns and distances of migrations vary between species e.g. peregrine falcon fly for 174 days, covering 15,000km (Johnsgard, 1990). Black kite is a short distance migrator. Some diurnal birds of prey migrate singly while others migrate in flocks. A few species are nomadic e.g. brown snake eagles inhabiting the African savanna.

Home range

Home range size during the breeding season depends largely on food availability. In general, if prey is abundant near the nest, home range size is small and vice versa. Differences in home range size exist between species and within species. In some regions of Africa where prey is abundant, black eagles have an average home range size of 10.5 square km (Newton, 1979). In other areas where prey is harder to come by, black eagle home ranges can be as large as 260 square km (Newton, 1979). Generally, the larger the species the larger the home range. Birds will defend part or the entire breeding home range e.g. red-tailed hawk defends the entire home range.

Body shape and coloration

In general, the bodies of diurnal birds of prey are fusiform in shape. This shape reduces drag while flying. Most diurnal birds of prey have subdued feather colors, mainly browns, rust, black, white, blue and gray. Males and females are usually identical in color except in some harriers and falcons. Many species have an immature plumage and an adult plumage.

Hind limbs

In birds of prey, the legs are well-muscled and sturdy for perching, and grasping prey. The first toe points backward and the other three forward. The toes are strong and each has a claw, or talon which are usually sharp & curved downward for catching and carrying prey. Red-tailed hawks usually deliver a death blow to a prey animal with their talons. Other raptors, such as peregrine falcons use a combination of their talons and their beak to kill a prey animal.

Fore limbs

These are modified into wings. Wings are covered with feathers, providing a lightweight surface for lifting and propelling a bird in flight. Primary flight feathers are the largest

outermost feathers attached to the hand bones. Secondary flight feathers attach to and run the length of the forearm and provide most of the lift in flight. The alulae are 3-4 small feathers attached to the thumb bone. These help to increase lift by reducing air turbulence during flight. The wings of many diurnal birds of prey have a vestigial claw located at the end of the thumb bone.

Wing shape

Wing shape is an adaptation to a bird's foraging behavior. Falcons have relatively long, narrow, sharply angled wings for chasing or stooping (diving) on prey. Majority of hawks and eagles have broad, rounded wings for high soaring on air currents. This type of wing doesn't produce great speed and so these birds rely on surprise when catching prey. Hawks of the genus *Accipiter* have relatively short, rounded wings for short bursts of speed and maneuverability while chasing prey in dense vegetation.

Beak

The bird's beak, or bill, is made of bone and covered by keratin. In raptors, the beak is strongly hooked at the tip and sharp edged for ripping and tearing apart the flesh of their prey. In falcons, the upper beak is notched, forming a "tooth". This "tooth" is used to break the cervical vertebrae of captured prey in order to prevent escape attempts. The base of the upper bill is soft and fleshy, forming the cere, which is an adaptation to a meat-eating diet. At the base of the upper bill (in the cere) are the pair nostrils. In falcons, the nostrils have bony tubercles that may act like air baffles, slowing airflow through the nasal passages during high speed stoops.

Eyes

In raptors, the eyes are set on either side of the head, facing forward. A nictitating membrane spreads fluid across the eye, keeping the eye moist. Raptors most likely use the membrane when flying on windy days or when dust and debris are in the air. Most raptors have a distinctive shelf or "eyebrow" above and in front of the eye which is thought to shade the eye from the sun and provide some physical protection. In these birds, the eyes are proportionally larger than those of other vertebrates, providing larger and sharper visual images. The retina has more rods and cones and is one-half to two times thicker than those of mammals. These birds have more sensory cells in the upper half of the retina to perceive images when looking toward the ground from a perch or when flying.

Tail

Tail feathers attach to the pygostyle (tail bone). In raptors, tails (just like the wings) create lift and balance in flight and are also used as a rudder for turning, and a brake for landing. Species

that dependent on fast, open flight to catch prey (e.g. falcons) tend to have short tails. Those that need quick maneuverability pursuing prey through bush have long tails (e.g. Accipiter hawks).

Skin

Birds have thin skin with no sweat glands. Specialized cells in the skin produce feathers, scales, claws, and the outer layer of beaks. Stored fat in the skin helps prevent heat loss and provide energy during migration. Smooth muscles in the skin allow birds to fluff feathers when the weather is cold and spread feathers when flying, or press feathers against the body (to lose heat). Uropygial (preen gland) on the upper surface of the rump secretes oils that help waterproof feathers and condition exposed skin. Most vultures have featherless or sparsely feathered heads, which can be easily cleaned after feeding on carcasses. In most raptors, the feathers are molted in sequential patterns so at no time are the birds flightless.

Plumage

Plumage refers both to the layer of feathers that cover a bird and the pattern, color and arrangement of the feathers. Chicks are hatched with a natal down (down feathers), which is replaced by a juvenile plumage before they leave the nest. The juvenile plumage may then be replaced by adult plumage or a number of immature plumages, depending upon the species. Bald eagles take four or five years to reach adult plumage (Scott, 1987).

Special senses

In raptors, sight is the most important sense for hunting and reacting to danger (thought to see objects up to three times better than humans). They focus on objects through binocular vision; but, can easily detect movement at the edges of their viewing range using just one eye. These birds are able to see color. This is important in food identification and reproductive behavior. Birds in general have an acute sense of taste; detect sweet, salt, sour, and bitter tastes. Most diurnal birds of prey aren't sensitive to smell; an exception is the turkey vulture, which is able to locate carrion from the air by smell alone (Brooke and Birkhead, 1991).

Bones

In birds, many of the bones are fused or modified for greater strength and rigidity. This is especially important for flying and perching. The sternum is greatly developed with a large flattened keel for the attachment of flight muscles. The wing attaches to the body via a sturdy pectoral girdle comprising of three bones namely clavicle, coracoid and humerus. The clavicle unites to form the furcula/ "wish bone" which provides support for the shoulders. The pelvic girdle consists of two coxae which unites with the vertebrae dorsally and does not meet its fellow ventrally. This facilitates egg laying. In the neck, the vertebrae are not fused; more

neckvertebrae means increased mobility of the head and neck. Many of the bones, including those in the skull, humerus, clavicle, keel, pelvic girdle, lumbar and sacral vertebrae are air-filled (pneumatized) and light, an adaptation for flight.

Muscles

Major muscles are situated close to the bird's center of gravity for proper balance. The flight muscles are located in the breast area and attach to the keel (m. pectoralis pushes the wing downward while m. supracoracoideus raises the wing). In raptors, the flight muscles are red, not white, as in chickens or turkeys, due to the abundance of oxygen-carrying myoglobin. In these birds also, the leg muscles are strong for grasping and carrying prey, and the toes and talons are controlled by a complex series of tendons attached to muscles in the upper part of the leg. The jaw and neck muscles are substantial and used for tearing and eating flesh. At the tail, a complex rump muscles raise, lower, and spread the tail during flight, take offs, landings, and courtship.

Brain

Being called a bird brain isn't necessarily a bad thing -- in fact, some may take it as a compliment! Birds are in fact extremely intelligent creatures, and as any bird owner knows, they never fail to surprise us with their capacity for learning. Important and relatively large structures of the brain include the cerebral hemispheres, optic lobes, and cerebellum. The cerebrum controls most of the body's activities as well as instinctive and conditioned behavior. The optic lobes receive and process sensory information from the eyes. They control eye and neck muscles, enabling birds to quickly track moving objects or avoid danger. The cerebellum controls the bird's posture and balance.

Circulatory system

This system consists of a heart plus vessels that transport blood. Birds have a 4-chambered heart (like mammals) which is proportionately larger and more powerful due to their higher metabolic rates. Because birds are such high-energy animals, their hearts beat much faster than those of mammals- some have a resting heart rate of over 500 beats per minute! Birds require large amounts of energy for flight, and need efficient oxygen circulation in high altitudes. The highest flight recorded for a bird was 11,274m when a Ruppell's griffon vulture collided into a commercial airline over Western Africa (Martin, 1987). Birds maintain a body temperature of 38- 42°C (Brooke and Birkhead, 1991).

Digestive system

This system comprises of the mouth (with no teeth), oesophagus (with a crop), stomach, small intestines, ceca, large intestines (colon), cloaca and also the liver and pancreas. The

crop is pouch-like enlargement of the oesophagus where food is stored before being passed into the stomach (absent in owls). The stomach has two chambers; glandular chamber, the proventriculus, which produces gastric juices for chemical digestion and a muscular compartment, the gizzard, which carries out mechanical digestion of food. The gizzard in most diurnal birds of prey is relatively thin-walled and sac-like due to the soft nature of meat. It is however heavily muscled with grit, pebbles, or sand in insect and grain eaters. The intestines of meat-eating birds are shorter than those of grain or fish eaters. The cloaca is the cavity where the urinary, intestinal and genital tracts empty i.e. where urates (avian urine) and digestive excrements mix to form the bird's feces expelled via anus or vent.

Regurgitation

While diurnal raptors generally tear up their food before swallowing it, owls usually swallow their prey whole. Luckily, the enzymes of the proventriculus (glandular stomach) can dissolve most of a prey's tissue and small bones, but not the fur or feathers. All non-digested food is trapped in the gizzard, forming a pellet (ball) that the raptor will eventually regurgitate (cough up). The bird's digestive system usually takes about one day to transform a prey into a pellet. Since owl stomachs are less acidic than those of diurnal raptors like hawks or falcons, they produce pellets with more bones and more complete skeletons.

Respiratory system

This consists of the nostrils, nasal cavity, oropharynx, anterior larynx, trachea, syrinx, bronchus, lungs and the air sacs. Birds have a parabronchial lung (mammals alveolar), which is light and adapted for flight. The avian lung does not change in volume during inspiration and expiration (is non-tidal). The air sacs (balloon-like structures at the "ends" of airway system) act as bellows to suck air in and blow it out. Gaseous exchange in the avian takes place (at the parabronchi) during both inspiration and expiration. In the avian therefore, gaseous exchange and ventilatory mechanisms separate i.e. gaseous exchange occurs in the air /blood capillaries of the lungs while ventilation is done by the air sacs.

Female reproductive system

The female reproductive system of the chicken is divided into two main parts: the ovary and the oviduct. In the majority of avian species, including chickens, only the left ovary and oviduct are functional. The oviduct is a long convoluted tube divided into infundibulum, magnum, isthmus, shell gland (uterus), and vagina. The infundibulum engulfs the ovum (egg) released from the ovary and is also a reservoir for spermatozoa. In the magnum, the thick white or albumen is added while in the isthmus, the inner and outer shell membranes are added to the egg. It is in the shell gland where the shell is placed on the egg. Pigment

deposition is also done in this region. The vagina is made of muscle and helps push the egg out of the hen's body.

Male reproductive system

The avian male reproductive system is all inside the bird. Male birds have two testes, along the back, near the anterior ends of the kidneys. Each ductus deferens opens into a small bump, or papilla, which is on the dorsal wall of the cloaca. The papillae serve as the copulatory organ.

Flight behavior

In general raptors are swift, capable and agile flyers. Peregrine falcons fly at high altitudes and dramatically dive, or stoop, at birds with their wings nearly closed. Golden eagles usually fly low and pounce suddenly on prey such as birds and rabbits. Red-tailed hawks can swoop down from a perch to catch prey or hover in one spot by flapping against a breeze before diving after a prey animal. Condors fly effortlessly for hundreds of miles in search of food—they do so by efficiently riding thermal currents.

Vocalization

Both male and female diurnal birds of prey typically vocalize in defense of territory and when courting mates. Except for a few species, like the chanting goshawks, the vocals are not melodic, but a series of short, loud calls or whistles. New World vultures vocalize through wheezes, snorts, and hisses, due to their lack of a syrinx.

Food resources

Birds of prey eat some type of animal flesh, including reptiles, insects, fish, birds, mammals, molluscs, and carrion. Groups of birds favor certain food e.g. larger falcons and Accipiter hawks eat mostly birds. Buteo hawks tend to feed on mammals, such as mice, voles, ground squirrels, rats, rabbits, and gophers. Most Old and New World vultures prefer to eat carrion. In general, raptors feed on game that average 12-50% of their body weight. In many species the female is larger than the male and therefore captures and consumes larger prey. Food intake increases in cold weather, before migration, and before egg laying (in females). Smaller birds usually eat proportionately more food than larger birds to maintain their metabolism and body temperature.

Hunting behavior

Majority of diurnal birds of prey hunt independently, and capture and kill game with their talons (+ beak in falcons). Group hunting has been observed in wintering Harris' hawks, where individuals cooperate to flush and ambush prey. When attacking from a stoop, the peregrine falcon will strike its prey (a bird) with a hind talon, knocking it to the ground.

Peregrines are the world's fastest moving bird, reaching speeds up to 180 kph when stooping (Martin, 1987). In addition to capturing their own prey, many birds, including peregrine falcons and bald eagles, steal prey from other birds. Once the prey is subdued, the bird usually "mantles", spreading its wings out and over the prey. Mantling shields the prey from theft by other birds. Many bird-eating species pluck the larger feathers before tearing and consuming the prey.

Breeding

Most diurnal birds of prey are monogamous i.e. keep the same mate for several years. A few species are polygynous (a male mates with more than one female at a time) e.g. many harriers. Others like the Harris' and Galapagos hawks are polyandrous (the female mates with more than one male at a time). The breeding season is marked by an increase in aerial displays and the male and female spending more time around the nest-site. Diurnal birds of prey breed during the time of the year when food is most available for raising young. They usually lay eggs in spring or early summer; but, the actual months differ depending on geographic location.

Nest building

Nest building varies between species. Most species build stick nests either in trees, on cliffs, on human made platforms, or on the ground. New World vultures scrape out a hollow usually in a tree or cliff cavity. Falcons use old nests of other species. Some pairs use the same nests year after year. Bald eagles reuse nests, adding sticks and greenery each year. The largest nest ever recorded was a bald eagle nest measuring 2.9m wide, 6m deep and weighing more than 3,000 kg (Martin, 1987).

Egg laying

Most species raise one brood per year. In general, large species produce small clutches (group of eggs). Small falcons, Accipiter hawks, and harriers usually lay 4-6 eggs in a clutch while larger members lay 3-4 eggs. Small kites lay 3-5 eggs while large kites, Buteo hawks, caracaras, and ospreys lay 2-3. Eagles and small vultures lay 1-2 eggs. Large vultures and condors lay only 1 egg per clutch. Small species lay an egg once every two days, while large species lay an egg once every three to five days. Most females incubate the eggs while the male provides food for himself and the female (vultures tend to share incubation between the male and female). Incubation lasts 4-7 weeks with the large species having longer incubation periods.

Lifespan

Little is known about the longevity of diurnal birds of prey in the wild. In captivity, one banded osprey lived 32 years, a golden eagle lived 25 years, and a honey buzzard lived 29 years (Welty, 1982). In general, small falcons and Accipiter hawks live about 15 years. Medium-sized buzzards and kites live 20 to 40 years, and large vultures and eagles have occasionally lived 40 to 55 years (Newton, 1979).

Predation

Diurnal birds of prey are often victim to other, larger birds of prey, including owls. Goshawks eat a variety of diurnal birds of prey including kestrels, buzzards, and kites. Eagle owls feed on buzzards, kestrels, kites, goshawks, and other owls. In sparrow hawks, the larger, mated female will prey on unmated males of the same species that try to court her. Eggs and young are vulnerable to predation by other birds, mammals, and reptiles.

Human interaction

Millions of diurnal birds of prey have been shot over the past 150 years; they have been persecuted for killing livestock, poultry, and game birds. In truth, only a few of the larger species occasionally feed on domestic animals. Others like the California condor were shot for their feathers or for sport. Deforestation and other habitat destruction is currently the most serious threat to diurnal birds of prey. Power line electrocution is frequent in larger birds, like vultures and eagles, whose wings can touch two wires at once. Many carrion-eaters are struck by cars while feeding on or near roads. The practice of removing or burning dead livestock has inadvertently reduced the food supply of many scavengers.

Pollution and poisoning

Diurnal birds of prey are especially vulnerable to pesticides, insecticides, and other human made toxic chemicals. Other forms of pollution, such as acid rain and oil spills, cause prey populations to decline, and in turn cause the decline of diurnal birds of prey populations. Diurnal birds of prey may be deliberately or accidentally poisoned- this is practiced in many areas of the world. Accidental poisoning occurs when diurnal birds of prey eat rodents or seed-eating birds that have been poisoned by farmers for pest control. Lead poisoning occurs when diurnal birds of prey eat carcasses or live prey shot with lead bullets. In the U.S., there's been a gradual elimination of lead from shotgun shells since the mid-1980s. Diurnal birds of prey may also be killed by eating poison-laced carcasses set by ranchers for coyotes, wolves, jackals, or other animals considered pests. Some carcasses are set deliberately for diurnal birds of prey.

Avian Anatomy & Veterinary forensics

Knowledge in Avian Anatomy is important in investigating and establishing facts of interest in relation to legal disputes (involving criminal and civil law). It helps veterinarians to assist investigators of animal cruelty with crime scene investigation and in the examination of live and deceased victims. Consultations are on cases involving but not limited to the following: injuries to animals by poacher, injuries to humans and livestock by raptors (game), death of raptors due to poisoning and issues to do with game meat.