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CHAPTER 61

Giraffidae

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BIOLOGY[15,47]

Two species exist within the artiodactylid family of Giraffidae; the giraffe (*Giraffa camelopardalis*) and the okapi (*Okapia johnstoni*). Giraffids first arose eight million years ago during the Miocene period, and fossil evidence suggests that the family was once much more extensive, with over 10 fossil genera described.

Up to nine races or subspecies of giraffe have been described, although genetic research and the fact that distinct morphologic distinctions between groupings exist despite the lack of physical boundaries have led some authorities to consider several distinct species. The subspecies most commonly held by zoos are the reticulated giraffe (*Giraffa camelopardalis reticulata*), the Rothschild giraffe (*G.c. rothschildi*), and the Masai giraffe (*G.c. tippelskirchi*). Once widespread across the African continent, giraffes are now largely confined to national parks and game farms in eastern and southern Africa, with scattered populations in west Africa.

Because of its height, the giraffe has access to browse unavailable to other species and thus may coexist with grazers and smaller browsers and even livestock. Adult giraffes are rarely preyed upon by predators, but calf mortality is high. Giraffes are sociable animals usually found in dynamic, ever-changing groups, the most stable of which are those composed by mothers and their young. Subadult males are social, whereas mature males become more solitary.

With an estimated 80,000 animals left in the wild, the giraffe is classified by the International Union for the Conservation of Nature (IUCN) as a species "Of Least Concern." However, several of the subspecies are now considered "Endangered" (e.g., West African and Rothschild). At least 2000 giraffes are maintained in captivity, making the captive population self-sustaining.

Discovered by science only as recently as 1901, the okapi was the last large African mammal species to be described. The okapi is now endemic to the Democratic Republic of the Congo in central Africa, where they inhabit dense damp forests on both sides of the Congo River. Okapis are diurnal and live alone, in pairs, or in small family groups, but relatively little is known about their social structure, largely because of their remote habitat and timid nature. Estimated remaining wild population is between 10,000 and 35,000, and the fate of these animals is closely linked to the unstable political climate of the region. The okapi is listed as "Near Threatened" by the IUCN but is not listed on the Convention on International Trade in Endangered Species (CITES) Appendix. With less than 200 animals in captivity, the okapi population is considered fragile.

UNIQUE ANATOMY[15,47]

Giraffe

With a height of up to more than 5 meters (m), giraffes are characterized by their extremely long necks and long legs, with considerably longer forelimbs than hindlimbs. The head is fairly small, with two horns or ossicones and a central osseous protuberance, which is particularly developed in the males. The tongue is long and flexible, its distal 20 cm pigmented. Mature males weigh 850 to 1950 kilograms (kg) and females 700 to 1200 kg. The internal anatomy of giraffes is analogous to that of the domestic cow and other artiodactylids. The dental formula for giraffes is incisors (I) 0/3, canines (C) 0/1, premolars (P) 3/3, molars (M) 3/3, for a total of 33. Often, the gallbladder is absent, although it occurs in some individuals. Two jugular veins run immediately under the skin on either side of the ventral neck.

The skin varies in thickness from being thin on the ears and medial aspects of the legs to being thick along the neck and lateral body. The thick skin aids in edema prevention in the lower leg and forms a dermal armor for protection against predators or fighting with conspecifics. The dark patches of the skin have been suggested to have a thermoregulatory role in acting as regions where heat loss to the environment is enabled by selective vasodilation.

The relative lung mass as well as volume is only approximately 60% of that of other mammals, and the lung volume-to-body mass ratio decreases during growth.[43] The extremely long trachea has a diameter significantly narrower than in similar-sized mammals, so the dead space volume, although greater than in most species, is not as large as could be expected and is compensated for by a slightly larger tidal volume.[43]

Previously described as extraordinarily large, the giraffe heart has a relative weight of approximately. 0.5% of body weight, which is essentially identical to that of other mammals.[42] The basis for the massive blood pressure generated is smaller ventricular radii and an unusually thick left ventricular wall with oblique muscle fibers. The giraffe vein has a venous valve layout similar to that in other large mammals, and no arterial valves exist.[49]

Okapi

The okapi reaches a head-to-body length of 200 to 210 cm and a shoulder height of 150 to 170 cm and has a body weight of 200–300 kg. Females are larger than males. The eyes and ears are large, and the tongue long enough to reach the ear base. Males have a pair of short-haired ossicones that are directed backward. The body is short and compact with a sloping back, as in the giraffe, but the neck is much shorter. Available information on okapi anatomy and physiology is limited, but the dental formula and internal anatomy resemble those of the giraffe.

UNIQUE PHYSIOLOGY[6,29,42,43,49]

To compensate for the hydrostatic challenge of perfusing the brain, the giraffe heart generates a blood pressure twice that of other mammals, and its cardiovascular anatomy and physiology have been subject to considerable speculation and myths. Both stroke volume and cardiac output are lower than in similar-sized mammals. Blood volume is unusually low, and compliance of the vascular system is also low. The peculiar vascular anatomy—with narrow, rigid veins with low compliance in the legs and large, compliant veins in the neck region—gives rise to an interesting and nonintuitive physiologic phenomenon.[6] When the head of the anesthetized giraffe is lowered, blood pressure at head-level briefly spikes, before returning to much lower values. The lowering of the blood pressure coincides with pooling of blood in the compliant jugular veins, giving rise to a decreased cardiac preload and consequently lower systemic blood pressure (Frank-Starling mechanism). As a consequence of this mechanism, the arterial pressure at head level is maintained at or near 100 millimeters of mercury (mm Hg), and the central blood pressure is directly proportional to the position of the head relative to the heart. Because of the high arterial pressures and the hydrostatic pressure, the arterial pressure in the lower leg may exceed 450 mm Hg. Edema in this region is prevented through a gravity-suit-like fascia and skin, prominent lymphatics, and well-developed valves in veins and lymphatics, as well as an abrupt narrowing of the arterial lumen at the level of the elbow or stifle.

The giraffe kidney experiences much higher pressures compared with the human kidney and appears to cope with this through a fibrous capsule and an increased interstitial pressure of about 30 to 40 mm Hg. This means that normal kidney perfusion depends on a mean arterial pressure of at least 130 mm Hg.

Similar to camels, the giraffe is capable of varying the body temperature within a couple of degrees Celsius, saving energy otherwise needed for increasing the temperature at night and cooling during daytime.

SPECIAL HOUSING REQUIREMENTS[9]

Giraffes may learn to lower their heads to walk through doors only slightly higher than their withers; however, stressed or sedated animals will often not do this, which necessitates high doors for a giraffe house.

Soft flooring and lack of exercise may lead to overgrowth of feet and the need for trimming, so the giraffe should be encouraged to walk on abrasive surfaces. Coarse gravel may be used on top of concrete to provide traction and wear. Neonates require sure footing and do best when born on pasture or a thick layer of bedding to prevent splaying.

Giraffes have a high surface-to-volume ratio and are adapted to tropical climates. In moderate climates, they may be maintained in outdoor enclosures year-round. In temperate climates, access to stables heated to the range of 18°C to 24°C (65°F–75°F) must be provided, and in subzero temperatures, outdoor access should be restricted.

Both okapis and giraffes are prone to sterotypies, particularly those involving the tongue, and it is important to incorporate in enclosure design pulleys and other systems to provide browse and enrichment items at head level. When designing facilities for giraffids, the logistics of loading and unloading animals should also be considered. Ideally, narrow walkways leading to an appropriate docking ramp for transport vehicles should be incorporated into the design.

FEEDING

Both giraffes and okapis are selective browsers seeking out the high-nutrient components of plants such as fresh leaves and buds. In the wild, giraffes mainly feed on Acacia species, and the natural diet of the okapi includes a variety of species. In an attempt to avoid negative energy balance, captive diets have traditionally contained high levels of protein (15%–20%) and starch (20%–30%). Based on wild diets, current recommendations include crude protein levels of only 10%–14%, starch levels below 5%, fat 2%–5%, and high amounts of fiber (minimally 25% acid detergent fiber) all based on a dry-matter basis.[58] Care should be taken to keep calcium levels high and phosphorus levels low. The new diet regimens have recently been shown to lead to increased serum levels of magnesium as well as n3 and n6 fatty acids and decreased levels of phosphorus and saturated fatty acids[36,41] so that blood nutrient profiles more closely match those of free-ranging giraffe.[36]

The importance of browse, for both the nutritional value and the behavioral well-being of animals, cannot be overstated and browse should be provided to the greatest extent possible, but good-quality hay and alfalfa as well as silage may be substituted. Surplus buds and twigs from rose growers have been used successfully in okapis.[59] The precise mineral and vitamin requirements of giraffids have not been established, but animals should have access to trace mineral salt blocks, and copper supplementation should be considered if deficiencies are suspected.

RESTRAINT AND HANDLING

Giraffes may be quite tame and may become habituated to some manipulation, including blood sample collection and light hoof trimming; however, many individuals do not respond well to this approach. The safest nonchemical method for collecting routine samples and closely examining animals is to accustom them to a chute during daily routines. Forced physical restraint without specialized stalls or chutes is likely to be unsuccessful and dangerous. Giraffes may deliver a formidable kick with all four legs in essentially any direction. In tall narrow chutes, with secure footing for personnel as well as animals, giraffes may be physically restrained for minor procedures such as injections, blood collections, tuberculosis testing and so on, but the risks involved for the animal as well as the staff should be kept in mind. Okapis respond well to training and positive reinforcement and poorly to physical restraint.

Once they get started, giraffes have the tendency to keep walking along hallways and so on, which may be exploited for crating or loading into vehicles. A curtain with a weight at the bottom, which will fall from a horizontal position to a vertical position behind the animal when released, may be helpful to encourage the animal to take that last step into an unknown crate.

CHEMICAL RESTRAINT

Giraffe anesthesia remains a challenge because of considerations of size as well as the peculiar anatomy and physiology of these animals; however, several good protocols and excellent information resources are now available.[12]

Standing Sedation

Standing sedation may work well, but ataxia may develop, so it is important to be prepared for the animal to go down unexpectedly. A chute or restraint device is ideal, but a large door that can close off a triangular space may provide a similar confined area. Several drug combinations have been used with success for procedures such as clinical examinations, hoof trimming, reproductive manipulation, minor surgery, and catheter placement (Table 61-1).

Immobilization and Anesthesia

Two main schools in giraffe anesthesia exist: (1) opioid-based protocols[7,11,66,67] and (2) ketamine, combined with high-dose medetetomidine.[8,39] The latter approach has been popular over the past decade because of the avoidance of an opioid component and relatively smooth inductions; however, it may result in hypertension and tachypnea, and re-sedation from medetomidine as the reversal agent wears off is a real concern. The opioids, however, may induce excitation and hyperthermia if underdosed and result in hypoventilation when used in high dosages. A compromise, which involves incorporating opioids, ketamine, and α_2-agonists in one protocol, appears to be the best solution so far.[11,24] Refer to Table 61-1 for suggested protocols.

The giraffe has traditionally been considered one of the most challenging animals to anesthetize, and most problems arise during induction and recovery. The key to success is careful planning and the availability of trained personnel and necessary equipment. The ideal induction occurs in a well-designed restraint device, which may be opened fully once the animal is recumbent. The second-best solution is a chute-system, where a halter may be placed on the sedated giraffe prior to induction, which will allow control of the head via a rope and pulley. The third-best option is to place a loop of thick rope around the base of the neck of the sedated animal and "walk" the animal to an open area with no obstacles, where it is made to walk in circles, with one to three handlers holding the rope. The animal is then tripped with another rope while still awake enough to maintain some control of the head during the fall. If neither of these options are available, the animal may be allowed to become recumbent in a padded stall or at least in an area without major obstacles. In either case, it is crucial to gain control of the animal's head as soon as it becomes recumbent, as most injuries occur when the heavily sedated giraffe attempts to stand and falls again.

For anesthetic induction in okapi, a padded restraint device is the safest option, but a quiet stall with sure footing will suffice. With opioid-based protocols, induction may sometimes result in excitement or tumbling. A staged approach, in which sedatives are allowed to set in for 15 to 20 minutes prior to opioid administration, is preferable, and once the opioid takes effect, two experienced helpers may use mild physical restraint with mattresses or boards to prevent injury.[12]

Regurgitation under anesthesia may be a concern in both giraffes and okapis, but particularly in the latter. The frequent early reports of regurgitation in okapis sedated with Immobilon (etorphine and acepromazine) was attributed to etorphine but likely largely was a reaction to acepromazine, which this author considers contraindicated in okapis. In animals fed mainly hay and pelleted feed, withholding food and water for 12 hours prior to a planned procedure is sufficient, but in animals eating large amounts of fresh browse, a 24-hour period is advisable. To minimize pulmonary compromise and ventilation–perfusion mismatch, a sternal position is preferable, when feasible, but giraffes generally do well in lateral recumbency for shorter periods. To reduce the risk of regurgitation and to stabilize blood pressure (see Unique Physiology section), the head should be elevated 80 to 150 cm above heart level. The neck should be kept as straight as possible, and placement of a padded board or ladder under the shoulder and onto bales of straw or similar material works well for this purpose.

Performing endotracheal intubation is straightforward in giraffes. Direct visualization of the larynx is possible with the use of a long laryngoscope blade, and insertion of a relatively thin catheter to subsequently guide the endotracheal tube is a good option.[12] However, in giraffes larger than 350 to 400 kg, the fastest approach is to manually insert a stomach tube or similar device into the trachea and then thread the endotracheal tube over that. Appropriate endotracheal tube sizes are 20 to 25 millimeters (mm) for okapis and juvenile giraffes and 25 to 30 mm for adult giraffes.

Hypoventilation is often a concern, and oxygen should be provided, whenever possible. A Hudson demand valve or similar device will provide the animal with oxygen and allow intermittent ventilation, as needed. Even in animals breathing well, a "sigh" every 2 to 5 minutes appears to be beneficial to avoid alveolar closing and shunting. In animals not intubated, supplemental oxygen via a deep nasal cannula and flowing at one liter per 100 kilograms per minute is recommended.

For recovery, a quiet area with good footing should be provided. Adequate space should be available for the animal to swing its head forward as it gets onto its hindfeet, and obstacles should be removed to avoid injury if the animal falls over. Reversal agents may be given intramuscularly or intravenously (IM or IV), depending on the situation. The goal is to get the animal into sternal recumbency, with strong spontaneous ventilation as fast as possible, and to then keep it there as long as possible, ideally for 10 to 15 minutes. Keeping the animal blindfolded during this time helps prevent its attempts to stand prematurely. Doxapram (0.1 mg/kg, given rapidly IV) may be used to stimulate animals that are reluctant to get up.[24]

Capture[12,63]

The immobilization of free-ranging giraffes for capture purposes has little in common with controlled anesthesia for longer procedures in captive animals. The approach currently employed by most successful capture crews relies on massive dosing with potent opioids (etorphine, carfentanil, thiafentanil, or a combination) to reduce the time from darting to recumbency and subsequent skilled handling of the awake, but physically restrained, animal.[63] The giraffe is darted from the ground or, more commonly, from a helicopter, and typically the animal goes down within minutes, although some animals need to be cast with ropes. Soon after the giraffe becomes recumbent, it is blindfolded, ears plugged, and haltered and reversal agents are administered. Once the animal stands again after a few minutes, it is led with ropes into an open trailer used to be transported to a larger contained trailer that accommodates several animals. Refer to Table 61-1 for doses. Other methods incorporating ketamine, with or without medetomidine, to reduce the opioid dosage result in longer induction times but more controlled immobilization.[8,11] Recently, mass capture using a funnel system has been employed successfully for translocations.

Longer Procedures and Monitoring

Once immobilized, many minor procedures—such as diagnostic sampling, foot care, and assisted calving—may be performed. Supplementation is rarely necessary for the first 45 minutes, but after that, periodic intravenous ketamine (0.2 mg/kg) or etorphine or thiafentanil (0.5 microgram per kilogram [μg/kg]) may be used. However, for longer procedures, a continuous infusion of one or more of these drugs or in combination with guaifenesin is preferable, and additional monitoring is recommended. Inhalation anesthesia with isoflurane is another option, but reduced blood pressure and ataxia following recovery are potential concerns.

At a minimum, monitoring should include heart rate and rhythm, rate and depth of ventilations, and oxygen saturation by pulse oximetry. Indirect blood pressure may be measured with an appropriately sized blood pressure cuff placed around the tail base. Measurements may not be accurate but will provide a trend to help guide supplementary drug administration, fluid therapy, and head positioning. To ensure kidney perfusion, the mean arterial pressure should be maintained above 130 mm Hg. As mentioned under "Unique Physiology," lowering of the head will result in pooling of blood in the jugular veins and reduced blood pressure. Therefore,

TABLE 61-1

Protocols for Chemical Restraint Used in Giraffidae*

Generic Name	Dosage	Reversal Agent/Dosage	Reference/Comment
GIRAFFE STANDING SEDATION			
Xylazine (X)	0.1–0.2 milligram per kilogram, intramuscularly (mg/kg, IM)		Mild sedation (e.g., to allow calf to nurse)[19]
Azaperone (Aza)/ detomidine (D)	Aza: 0.2–0.5 mg/kg, IM D: 15–30 µg/kg, IM	Yohimbine 0.1–0.2 mg/kg, IV/IM; or atipamezole 0.01–0.05 mg/kg, IV/IM	[9,12] For deeper sedation, add butorphanol 10–25 µg/kg
Detomidine/ acepromazine (Ace)/ butorphanol (B)/ methadone (Met)	D: 30–40 µg/kg Ace: 15–25 µg/kg B: 20–30 µg/kg Met: 20–30 µg/kg	Atipamezole 0.03–0.06 mg/kg, IM/IV Naltrexone 40–60 µg/kg, IM/IV	[24] For deeper sedation, add xylazine 20–50 µg/kg
GIRAFFE ANESTHESIA†			
Xylazine/etorphine (E)/ ketamine (K) (etorphine may be replaced with carfentanil)	X: 0.05–0.1 mg/kg E: 5–8 µg/kg K: 0.5–1 mg/kg	Atipamezole 0.05 mg/kg, IM/IV Naltrexone 0.3 mg/kg, IM/IV	[24] Allow 10–20 minutes after xylazine before giving etorphine and ketamine
Medetomidine (Med)/ ketamine	Med:40–60 µg/kg, IM K: 1.0–1.5 mg/kg, IM (approximately equal to M: 150 µg + K 3/centimeters (cm) of shoulder height)	Atipamezole 0.05–0.15 mg/kg IV/IM	[8,39] Tachypnea common High potential for re-sedation from medetomidine Re-dose atipamezole at 4 hours, and if needed again at 8 hours
Thiafentanil/ketamine/ medetomidine	T: 5–6 µg/kg Med: 8–13µg/kg K: 0.6–1 mg/kg	Atipamezole 0.05 mg/kg Naltrexone 0.2 mg/kg	[5,11] Beware of potential re-sedation from medetomidine
GIRAFFE CAPTURE			
Etorphine or thiafentanil or 1:1 mix.	10–14 mg/sub-adult 14–15 mg/adult cow Up to 18 mg/adult bull	Naltrexone 0.3–0.4 mg/kg	[63] Immediate reversal required!
Thiafentanil/ketamine/ medetomidine	T: 6–10 µg/kg Med: 10–14 µg/kg K: 0.5 mg/kg	Atipamezole 0.05 mg/kg Naltrexone 0.2–0.3 mg/kg	[11] Beware of potential re-sedation from medetomidine
OKAPI STANDING SEDATION			
Xylazine/butorphanol	X: 0.4–0.8 mg/kg, IM B: 80–200 µg/kg, IM	Yohimbine 0.1–0.2 mg/kg, IV/IM; or atipamezole 0.05–0.1 mg/kg, IV/IM	[12] If indicated, reverse butorphanol with naltrexone 1–2 times dose of butorphanol, IM/IV
Detomidine/butorphanol	D: 40–100 µg/kg, IM B: 80–200 µg/kg, IM	Yohimbine 0.1–0.2 mg/kg, IV/IM; or atipamezole 0.05–0.1 mg/kg, IV/IM	[12] If indicated, reverse butorphanol with naltrexone 1–2 times dose of butorphanol, IM/IV
Xylazine/ketamine	X:0.4–0.6 mg/kg, IM K: 0.4–0.6 mg/kg, IM	Yohimbine 0.1–0.2 mg/kg, IV/IM; or atipamezole 0.03–0.6 mg/kg, IV/IM	[64] Normally, the animal will stay standing, but may lie down
Detomidine/butorphanol/ acepromazine/ midazolam (Mid)	D: 40–60 µg/kg B: 40–60 µg/kg Ace: 30–40 µg/kg Mid: 30–40 µg/kg	Atipamezole 0.03–0.06 mg/kg, IM/IV Naltrexone 40–60 µg/kg, IM/IV	[24]
OKAPI ANESTHESIA†			
Carfentanil/xylazine	X: 0.12 mg/kg C: 5 µg/kg, IM	Naltrexone 0.5 mg/kg, IM	[12] Allow 10–20 minutes after xylazine before giving C Add azaperone 50 mg/adult in stressed animals
Etorphine/xylazine 1:1	X: 0.1–0.2 mg/kg, IM E: 8–15 µg/kg, IM	Atipamezole 0.05 mg/kg, IM/IV Naltrexone 0.2–0.3 mg/kg, IM/IV	Allow 10–20 min after xylazine before giving etorphine Do not use Immobilon because of risk of regurgitation from acepromazine
Medetomidine/ketamine	Med: 60–120 µg/kg, IM K: 1–3 mg/kg, IM	Atipamezole 0.3–0.6 mg/kg, IV/IM	[12,45,64]

*Refer to text for details.
†Provide oxygen via deep nasal cannula or intubate.

lifting the head will typically result in an increase in blood pressure. Invasive blood pressure monitoring or arterial samples for blood gas determination are most easily obtained from the dorsal auricular artery. End-tidal carbon dioxide, functional oxygen saturation (pulse oximetry), and electrocardiography are also useful in monitoring prolonged anesthesia in giraffes.[12]

Long-Acting Tranquilizers

In both species, mild sedation for transport or introductions may be achieved with zuclopenthizole acetate (0.5 mg/kg IM, lasting 3 days) or zuclopenthixole decanoate (2 mg/kg IM, lasting 21 days).[24] In giraffes, haloperidol (15–20 mg/female, 20–30 mg/male IM, lasting 12–24 hours) is useful for loading, as animals will often start walking in 15–20 minutes.

SURGERY

Because of size considerations and the challenges of obtaining minimal ataxia during recovery, only a rather limited array of surgical interventions have been reported in giraffes. Tongue tip amputation, partial mandibular resection, mandibular ostrosynthesis, arthroscopy, arthrotomy, tenotomy, and castration have all been successfully performed.[5,55] Although cesarian sections have been performed, abdominal surgery in giraffes is generally challenging because of the short body making access difficult. A laparoscopic approach has been suggested,[53] but its application would likely be limited. Several cases of colonic obstruction have been documented, and aggressive supportive care and early surgical intervention have been advocated.[16] A glue-on hoof block was successfully used to treat a distal phalangeal fracture.[33]

For the okapi, which is a much better surgical candidate,[57] procedures have included fracture repair, rectal prolapse reduction, rumenotomy and abomasotomy for foreign body retrieval, and surgery for umbilical hernias.

DIAGNOSTICS

Most diagnostic techniques used for other large ungulates may be adapted for use in giraffids. Blood is readily obtained from the jugular vein or other sites such as the lateral saphenous vein. As mentioned previously, giraffes may be trained to accept blood sampling, typically from the jugular vein. In tractable okapis, blood may sometimes be drawn from an auricular vein using a butterfly needle. Indwelling catheters may be placed in the same locations, but long-term catheter maintenance is difficult in conscious adult animals.

Urine may be collected from female animals by direct catheterization by using techniques and catheters designed for cows. In males, urinary catheters may be placed only with extreme difficulty because of the long and narrow urethra and sigmoid flexure, so urine is usually collected opportunistically.

Radiography of the head, neck, and limbs is straightforward, but thoracic radiography is a challenge in giraffes simply because of their size.

Hematology (Table 61-2) and serum biochemistry (Table 61-3) reference values for giraffes and okapis were determined through compilation of MedARKS records from multiple institutions.[62]

INFECTIOUS DISEASE

In general, infectious diseases are not a major concern in giraffids maintained in captivity. Overall giraffids are susceptible to most diseases of domestic ruminants, but while several individual cases of infectious diseases have been reported, no real patterns or extreme susceptibilities exist.

Bacterial Diseases

Reported bacterial diseases include salmonellosis, paratuberculosis, brucellosis, anthrax, actinomycosis, listeriosis, Q-fever, and *Mycoplasma*-associated polyarthritis.[9,14,27] Both *Mycobacterium bovis* and *M. tuberculosis* have caused tuberculosis (TB) in giraffes. Intracutaneous TB testing appears to be sensitive and may be supplemented by serologic testing. Enteritis caused by *Escherichia coli* or *Clostridium perfringens* appears to occur with some frequency in okapis.[17,57] *Anaplasma marginale* infection appears to be a common subclinical infection in free-ranging giraffe.[46] Similarly, giraffes may be healthy carriers of *Ehrlichia* (*Cowdria*) *ruminantium* transmitted with *Amblyomma* sp. and do not develop clinical disease following artificial infection.[51]

Otitis, involving various bacteria and fungi, was seen in several okapis in one collection but not in 15 others, and environmental factors were suspected.[2]

Viral Diseases

Viral diseases reported in giraffes and okapis include rinderpest, to which giraffes are very susceptible,[9] malignant catarrhal fever, foot-and-mouth disease, encephalomyocarditis, and lumpy skin disease.

TABLE 61-2

Reference Ranges for Hematological Parameters for Giraffidae from Composite MedARKS records[62]

Parameter	Unit	Giraffe Mean ± Standard Deviation	Okapi Mean ± Standard Deviation
Leukocytes or white blood cell count	10^9/liter (L)	12.6 ± 4.8 (479)	8 ± 3 (91)
Neutrophils: bands	10^9/L	0.86 ± 1.2 (181)	0.11 ± 0.1 (14)
Neutrophils: segmented	10^9/L	9.2 ± 4.2 (446)	5.1 ± 2.5 (81)
Lymphocytes	10^9/L	2.3 ± 1.4 (451)	2.4 ± 1 (81)
Eosinophils	10^9/L	0.40 ± 0.40 (266)	0.16 ± 0.11 (32)
Monocytes	10^9/L	0.41 ± 0.37 (370)	0.29 ± 0.31 (70)
Basophils	10^9/L	0.29 ± 0.22 (255)	0.15 ± 0.09 (18)
Hematocrit or packed cell volume	Liter per liter (L/L)	0.35 ± 0.06 (550)	0.36 ± 0.08 (92)
Erythrocytes or red blood cell count	10^{12}/L	10.5 ± 2.4 (350)	10.0 ± 2.7 (80)
Hemoglobin	Gram per liter (g/L)	119 ± 18 (376)	124 ± 27 (90)
Mean corpuscular hemoglobin	Picogram per cell (pg/cell)	11.7 ± 2.7 (340)	12.7 ± 1.7 (79)
Mean corpuscular hemoglobin concentration	g/L	348 ± 35 (373)	347 ± 29 (89)
Mean corpuscular volume	Femtoliters (fL)	34.1 ± 8.4 (346)	36.7 ± 4.1 (78)
Platelets	10^{12}/L	0.42 ± 0.17 (93)	0.38 ± 0.11 (20)

Note: Values represent mean ± standard deviation (n).

TABLE 61-3

Reference Ranges for Serum Biochemical Parameters for Giraffidae Based on Composite MedARKS records[62]

Parameter	Unit	Giraffe Mean ± Standard Deviation	Okapi Mean ± Standard Deviation
Total protein	Gram per liter (g/L)	74 ± 14 (312)	71 ± 10 (77)
Albumin	g/L	31 ± 5 (282)	31 ± 8 (61)
Globulin	g/L	42 ± 14 (280)	40 ± 10 (59)
Fibrinogen	g/L	2.3 ± 1.8 (135)	0.4 ± 0.9 (33)
Glucose	Millimole per liter (mmol/L)	7.7 ± 3.3 (434)	7.2 ± 2.4 (83)
Alanine aminotransferase	Unit per liter (Unit/L)	13 ± 11 (237)	17 ± 20 (73)
Alkaline phosphatase	Unit /L	522 ± 476 (388)	397 ± 547 (77)
Aspartate aminotransferase	Unit /L	96 ± 55 (393)	66 ± 36 (77)
Creatine phosphokinase	Unit /L	1356 ± 1677(198)	615 ± 612 (77)
Gamma glutamyltransferase	Unit /L	61 ± 82 (207)	58 ± 101 (57)
Lactate dehydrogenase	Unit /L	864 ± 650 (235)	522 ± 296 (41)
Blood urea nitrogen	mmol/L	7.1 ± 2.5 (417)	7.5 ± 2.9 (80)
Creatinine	Micromole per liter (µmol/L)	159 ± 44 (373)	194 ± 71 (39)
Iron	µmol/L	16.7 ± 12.5 (28)	25.1 ± 9 (14)
Calcium	mmol/L	2.50 ± 0.45 (404)	2.58 ± 0.40 (80)
Phosphorus	mmol/L	3.0 ± 0.8 (372)	2.6 ± 0.7 (74)
Magnesium	mmol/L	1 ± 0.2 (63)	1 ± 0.3 (7)
Potassium	mmol/L	4.8 ± 0.6 (379)	5.0 ± 0.5 (77)
Sodium	mmol/L	145 ± 4 (381)	142 ± 5 (76)
Chloride	mmol/L	104 ± 6 (358)	103 ± 6 (74)
Triglyceride	mmol/L	0.45 ± 0.3 (245)	0.37 ± 0.3 (35)
Bilirubin: Total	µmol/L	17 ± 15 (377)	7 ± 5 (75)

Note: Values represent mean ± standard deviation (n).

A rotavirus was commonly involved in diarrhea in okapi calves in the 1980s and 1990s[56,57] but appears less prevalent now. Another rotavirus closely related to bovine rotavirus was recently isolated from a giraffe calf with diarrhea.[44] Similarly, a coronavirus closely related to bovine coronavirus was isolated from several giraffes with diarrhea.[30] None of these infections appear to be of particular concern.

Equine herpes virus types 1 and 9 were found to cause severe nonsuppurative meningoencephalitis in giraffes, and it was suspected that the infection originated from zebras sharing the enclosures.[31,35]

Bovine papillomavirus (BPV-1 and -2) was identified in multifocal to coalescing nodular and occasionally ulcerated lesions of the head, neck, and trunk of two giraffes.[68] Lesions were similar to equine sarcoids and locally invaded the subcutis but did not appear to metastasize. A pestivirus related to bovine viral diarrhea (BVD) virus has been isolated from a giraffe but appears to have little clinical significance.[28]

An outbreak of papules, vesicles, and pustules in several okapi caused by an orthopoxvirus was described in the early 1970s[70] but has not been of major concern since then. A single case of bluetongue has been described in an okapi, while the giraffe does not appear to be susceptible. Vaccination appears effective and may be considered for okapi kept in endemic areas.

Parasitic Diseases

Multiple parasites have been described in both giraffes and okapis; however, none constitute major problems in captive animals. Giraffes appear to be susceptible to many of the parasites of domestic ruminants,[21] and both species respond well to treatment with anthelmintics used in domestic cattle. As with any species, these drugs should be used prudently, and resistance has proven to be a concern, as evidenced by the report of giraffe-derived *Haemonchus contortus* resistant to benzimidazoles, imidazothiazoles, and macrocyclic lactones.[22] Orally administered copper oxide wire particles provide an alternative treatment to traditional anthelmintics and have been used successfully as part of an anthelmintic strategy in several institutions.[22]

Originally identified in a fatal case, a *Cytauxzoon* sp. was retrieved from several normal free-ranging giraffes.[37] In contrast, novel species of *Babesia* and *Theileria* were identified in the blood of young semi–free-ranging giraffes and were suspected to be the cause of death in these animals.[48]

Other parasites reported in giraffes include multiple tick species, *Rhinoestrus* sp., *Sarcoptes scabei*, *Thelazia gulosa*, *Capillaria* sp., *Camelostrongylus mentulatus*, *Trichostrongylus axei*, *Ostertagia ostertagi*, *Teladorsagia circumcincta*, *Teladorsagia trifurcata*, *Monodontella giraffae*, *Marshallagia marshalli*, *Trichostrongylus vitrinus*, *Trichostrongylus colubriformis*, *Spiculopteragia asymmetrica*, *Trichuris giraffae*, *Parabronema skrjabini*, *Skrjabinema* sp., *Haemonchus mitchelli*, *Echinococcus* sp., *Cryptosporidium parvum*, *Giardia* sp., and *Hepatozoon* sp.[3,4,9,21,57]

NONINFECTIOUS DISEASE

Noninfectious problems are probably more prevalent than infectious disease in captive giraffids, and several "syndromes" are seen with some frequency. Congestive heart failure of unknown etiology has been diagnosed in several adult female okapis in a single collection.[1] Clinical signs were managed with oral furosemide and enalapril. Interestingly, myocardial hypertrophy or ventricular dilation was a frequent finding in a survey of postmortem findings.[17]

Both species are susceptible to overgrown hooves in captivity mainly because of lack of movement, dry environments, and shortage of sufficiently abrasive surfaces. Apart from simple overgrowth, excessively steep stance, crossing over of cleats, and flaring hoof

walls are the most common problems in okapis, whereas in giraffes crossing over of the cleats is the problem most commonly encountered. The hoof horn, particularly of giraffes, is extremely hard, and the use of power tools will significantly facilitate corrective trimming.

Gastrointestinal Disorders

Colic without specific etiology is seen with some frequency in okapis, and intestinal stasis following anesthetic events has been anecdotally reported.[64] Intestinal volvulus has been seen in both juvenile and adult okapis.[17]

Colonic obstruction with phytobezoars or fecal matter was documented in three giraffes[16] and has also been seen in okapis. The spiral colon appears to be particularly prone to these obstructions, and unless diagnosed and resolved early, these obstructions hold a poor prognosis.[16] In okapis, excessive maternal grooming of calves may lead to anal trauma and stricture.[59]

Giraffids, like other browsing ruminants, have lower chewing efficiency compared with grazers, and the feeding of traditional "grazer diets" leads to significantly larger mean fecal particle size in captive giraffes than in free-ranging giraffes.[32] It has been speculated that this deficient particle size reduction could contribute to potential clinical problems such as gastrointestinal blockage and bezoar formation.

Acute Mortality Syndrome

Acute mortality syndrome was a major cause of death in captive giraffes for decades,[34] but the frequency has decreased in recent years, largely because of improved feeding practices. Many animals died without any history of illness, others after a mild or short-term illness or stressful incident. Emaciation with serous atrophy of fat is the key pathologic finding, often accompanied by pulmonary edema, petechial hemorrhages, intestinal ulceration, and myocardial degeneration.[13] Essentially, this "syndrome" appears to be simply caused by a negative energy balance, either from insufficient nutrition[13] or poor dental health,[18] and the "last straw" or event triggering death may be hypothermia or stress.[34,54] Similar pathologic findings are observed in winter in free-ranging giraffes at the southern margin of their distribution and are interpreted as starvation. A similar phenomenon appears to exist in the okapi, and emaciation with serous atrophy of fat was noted in 17 of 134 okapi postmortem reports reviewed.[17]

Urolithiasis

Urolithiasis occurs with some frequency in captive giraffes, and some uroliths have been diagnosed as carbonate or apatite with a shell of struvite.[69] In a recent survey, 6 of 43 zoos reported a history of urolithiasis.[61] High dietary phosphorus content and a high level of concentrate relative to hay (>1) may be contributing factors to urolith formation.[61]

Chronic Interstitial Nephritis

Renal tubular atrophy, with conical and medullary interstitial fibrosis and severe thickening of the basement membranes of atrophic tubules, has been described in several okapis.[25,26] Focal glomerular atrophy, probably secondary to ischemic collapse of the glomerular capillary tuft, was also observed. Although the etiologies and pathogenesis of these nephropathies are unclear, primary damage of the tubular epithelium appears to be the most likely cause, and toxicity from ingested plant material, possibly willow (*Salix* sp.), has been proposed as an etiologic factor.[26]

Glycosuria

Asymptomatic glycosuria is very prevalent in adult captive okapis,[20,23] whereas animals tested at the Epulu station (Democratic Republic of Congo) were nonglucosuric.[20] The etiology is unknown; animals have normal serum levels of insulin, glucose, and fructosamine, and no correlation with stress or dietary glucose content has been found.[65]

Neoplasia

Neoplasia is not frequently seen in giraffids. Neoplasms reported in giraffes include embryonal rhabdomyosarcoma, pelvic chondrosarcoma causing dystocia, umbilical cord teratoma, verrucous squamous cell carcinoma, and glioneuronal hamartoma in the mesencephalic aqueduct. Findings in okapis include luteoma, ependymoma, and phechromocytoma.

REPRODUCTION[10]

Giraffids are considered nonseasonal breeders, with a short cycle of approximately 15 days and a comparatively long gestation of 420 to 468 days in the giraffe and 414 to 491 days in the okapi. Females attain sexual maturity at an age of about 20 months. Under zoo conditions, both species may live up to an age of well over 30 years. Reproduction is discussed in Table 61-4.

The female giraffid has a bicornuate uterus. In the male, the testes are scrotal, and the penis is fibroelastic and has a long urethral process resembling that of a goat. Interestingly, three variations of chromosome numbers have been identified in the okapi (44, 45, 46).[52] The reduction of 46 chromosomes to 45 is the result of a Robertsonian translocation between chromosomes 8 and 21. Individuals with 45 and 46 have both reproduced successfully in mixed karyotype pairs. Females are nonseasonal breeders and come into estrus at 15-day intervals. Estrus behavior is fairly subtle and consists of mild mucus production and vulvar flaring. Breeding normally is uneventful, with copulation lasting only seconds.

Pregnancy may usually be detected visually about half way through. In trained animals, ovarian cycles and pregnancy may be monitored with transrectal ultrasonography.[40] In pregnant giraffes,

TABLE 61-4

Reproductive Characteristics of Giraffids[9,10,38,40]

Parameter	Giraffe	Okapi
Karyotype (2n)	30	44, 45, or 46[52]
Puberty, age (years)	Female at 3–4 Male at 4–5	Females at 2.5 Males at 2–4
Estrus cycle (days)	14–15	15–16
Luteal phase	8	11
Follicular phase	6	5
Duration of copulation	Few seconds	Few seconds
Gestation	420–468 days	414–491 days
Pregnancy determination	Urinary/fecal PdG	Urinary/fecal PdG
Placentation	Cotyledonary placentation	Cotyledonary placentation
Urinary pregnanediol-3-glucuronide (PdG), nanogram per milliliter (ng/mL)		
Nongravid:		
Follicular	3.6 ± 7 ng PdG/mg Cr	1.9 ± 0.1 ng PdG/mg Cr
Luteal	30.9 ± 1.7 ng PdG/mg Cr	27.2 ± 3.9 ng PdG/mg Cr
Gravid	Persistent luteal levels >250 ng PdG/mg Cr in late gestation	Persistent luteal levels With levels >100 ng PdG/mg Cr
Semen volume	4–6 mL	Unknown

the corpus luteum (CL) reaches a diameter significantly larger (40 mm) than during the cycle (33 mm), and follicular activity may still be present.[40] Transabdominal ultrasonography may detect later stage pregnancy. Pregnancy may also be detected by means of urinary and fecal steroid analysis.[38,60]

Predicting the time of birth precisely is difficult in giraffes. The udder typically, but not always, becomes enlarged in the last few weeks prior to parturition. Vulvar edema and a mucoid discharge may precede parturition by a few days. If possible, the female should be isolated from the herd shortly before parturition and remain separate with the calf for at least 24 hours, but if adequate space is available, the female may simply give birth while with the herd. Giraffids usually give birth to a single calf; however, twinning does occur. In the okapi, several twin pregnancies have ended in stillbirths.[59] Labor is usually short (3–6 hours), and the healthy calf should be standing within an hour or so of birth. The birthing environment is important for neonatal survival. A proper substrate of compacted soil, rubber pads, or straw bedding is important to prevent hypothermia and splaying. Nursing should start within the first few hours after birth. First-time mothers may be nervous and may at first refuse to allow the calf to suckle. They usually relax after a few hours, but mild sedation has been necessary in several instances.[19]

Neonatal examinations are useful for assessing the general health of the neonate and determining the success of immunoglobulin transfer from the dam. Normal birth weight is approximately 60 kg in the giraffe and 15 to 30 kg for okapis.

An okapi that experienced five abortions because of deficient placental progestagen production was treated with altrenogest in a subsequent pregnancy and carried the fetus to term.[60]

Retained placenta occurs with some frequency in both species, particularly when the calf is stillborn or dies within the first day. Ideally, as much of the placenta should be removed as possible, but cases have been managed with only supportive therapy, including antibiotics.[59]

Contraception

In some cases, preventing reproduction in giraffes is desirable. Surgical castration is an effective, although nonreversible, means of contraception in male giraffes. Open castration using an emasculator and ligation has been advocated, but partial or complete scrotal closure is probably a superior technique.[5]

For contraception in females, melengestrol acetate (2–3 mg/kg/day) administered in the feed, or the progesterone-derivative medroxyprogesterone acetate (Depo-Provera, Pfizer Animal Health), (450–800 mg/female, every 6 weeks) have been the traditional pharmaceutical means of contraception; however, the gonadotropin-releasing hormone (GnRH) agonist deslorelin (Suprelorin, Peptech Animal Health/Virbac) administered as implants has recently proven to be superior and effective for more than a year.[50] It is suggested to check the current recommendations of the Contraceptive Advisory Group before initiating contraception.

PREVENTIVE MEDICINE

Preventative measures in giraffids include regular inspections of feet and provision of abrasive surfaces. If necessary, routine foot care should be provided, ideally through use of training. Regular screening for intestinal parasites and deworming, if indicated, should be part of the strategy, and regular weighing of animals is highly recommended.

Routine vaccination is seldom performed, but vaccines against rabies, clostridial diseases, and bluetongue, as well as rotavirus and coronavirus, are sometimes used.

Preshipment testing is recommended for any giraffe relocation, but specific tests to be performed depend on local conditions. The following are recommended guidelines to aid in decision making when planning the safe transfer of a giraffe or okapi: (1) fecal sample for parasites, particularly nematodes; (2) fecal culture, especially for *Salmonella*; (3) tuberculin skin testing and auxiliary TB tests; (4) blood sample for complete blood cell (CBC) count and serum chemistries; (5) physical examination, including foot inspection. Intracutaneous TB testing may be performed in the eyelids, as in primates, to avoid the need for a second restraint of the animal.

Quarantine of individuals should be performed before exposure to animals at the new location.

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