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CHAPTER 47

Felidae

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BIOLOGY

The family Felidae consists of at least 36 wild cat species. These felids are morphologically similar with rounded, flat faces, facial whiskers, large eyes, and large ears. They have the widest range of body sizes of all living carnivore families, weighing 1 kilogram (kg) to 300 kg. They occupy diverse habitats and are distributed naturally throughout the world except Antarctica and Australia, where they have been introduced by humans.

Felid taxonomy has been intensively studied and yet remains controversial. The number of genera recognized is variable. Although in the past four genera were lumped together, currently at least 12 genera are recognized based on several studies of morphology and genetics.[31] Taxonomy and biostatistics for felids may be found in Table 47-1.

STATUS AND CONSERVATION

Wild felids are predators requiring large areas of habitat with suitable prey density. Human population growth has negatively impacted both these requirements, resulting in a decline in all felid species worldwide in range and number. Felidae are among the most threatened groups of mammals. Larger species are heavily persecuted because of the danger they pose to humans and livestock. Small cat species are also persecuted and are harvested for the fur trade. The International Union for the Conservation of Nature (IUCN) Red List designates 29 of 36 wild felid species as having a decreasing population trend. Nearly 50% of all felid species are listed in the top three threatened categories, and seven of these species are listed as Critically Endangered or Endangered. Felids characterized as threatened are those that appear to be naturally rare with limited distribution or those that have become threatened because of human factors. The Iberian lynx, listed as Critically Endangered, fits into both categories and may become the first cat species to become extinct in modern times.[23,31]

UNIQUE ANATOMY AND SPECIAL PHYSIOLOGY

The anatomy of nondomestic felids is similar to that of the domestic cat. Sexual dimorphism is limited with males generally 5% to 10% larger than females. There are 28 or 30 teeth with the following dental formula: incisors (I) 3/3, canines (C) 1/1, premolars (P) 2-3/2, molars (M) 1/1. The incisors are small and are used for nipping flesh from carcasses. Canines are long with a length-wise groove in the enamel and are used to kill prey. The fourth upper premolars (carnassial teeth) are used to slice meat. The reduced dentition allows for a reduced length of the skull and mandibles, which improves efficiency of the muscles that close the jaw. Cats have a more powerful bite relative to muscle mass than any other carnivore except mustelids. Because of their carnivorous diet, cats have a shorter digestive tract with a smaller cecum and a short large intestine.[31]

The forelimbs are used for locomotion and prey capture. To grasp prey, supination of the paw is needed. This increased mobility of the elbow and wrist joints affects running. Canids run faster as they have stiffer forelimbs. The hindlimbs are the propulsers, and the reduction or loss of a clavicle increases stride length. Cats are digitigrade, with five toes in the front and four in the back. The first digit on the front foot is the dewclaw. All felids have retractable claws, the exception being the cheetah, in which retraction is less developed. Cheetahs lack the fleshy sheath protecting the claw.[31]

A key characteristic that was used to separate the big cats (Pantherinae) from the small cats (Felinae) is the presence of an elastic ligament in the hyoid apparatus below the tongue, which was thought to allow the big cats to roar but not purr. Conversely, the bony hyoid of the small cats was thought to allow them to purr but not roar. More recent studies comparing the hyoid structure and vocal abilities dispute this correlation. It has been found that the main difference between the roaring, nonpurring cats and the others was the presence of long, fleshy, elastic vocal folds within the larynx

TABLE 47-1

Taxonomy and Biostatistics

Category*	Native Region	Genus and Species	Common Name	Longevity (Years)	Adult Mass (kg)	Gestation (Days)
		GENUS *FELIS*				
LC	Europe, Africa, Asia	*F. silvestris*	Wild cat	19	5.0–8.0	64–67
LC	North Africa to Indochina, Sri Lanka	*F. chaus*	Jungle cat	20	3.0–16	63–66
NT	North Africa, Arabia, Asia	*F. margarita*	Sand cat	13.9	2.75	67
VU	South Africa	*F. nigripes*	Black-footed cat	12	1.3–2.3	63–68
		GENUS *OTOCOLOBUS*				
NT	Iran to China	*O. manul*	Pallas cat	16	2.5–4.5	66–75
		GENUS *LYNX*				
LC	North America	*L. canadensis*	Canada lynx	17	8.0–18.0	62–74
LC	Europe, Asia	*L. lynx*	Eurasian lynx	24	18.0–30.0	67–74
CR	South Europe	*L. pardinus*	Iberian lynx	13	9.0–27.0	60
LC	North America	*L. rufus*	Bobcat	32	4.0–18.0	60–70
		GENUS *CARACAL*				
LC	Africa, Arabia, Asia	*C. caracal*	Caracal	17	9.0–18.0	78–81
NT	West Africa, Central Africa	*C. aurata*	African golden cat	21	5.5–16.0	75
		GENUS *LEPTAILURUS*				
LC	Africa	L. serval	Serval	23	7.0–18.0	66–77
		GENUS *PARDOFELIS*				
VU	South Asia, Southeast Asia	*P. marmorata*	Marbled cat	12	2.0–5.0	66–82
EN	Borneo	*P. badia*	Bornean bay cat	No data	3.0–4.0	70–75
NT	Southeast Asia	*P. temminckii*	Asian golden cat	23	9.0–16.0	91–95
		GENUS *PRIONAILURUS*				
LC	South Asia, East Asia	*P. bengalensis*	Leopard cat	17	3.0–7.0	65–72
VU	India, Sri Lanka	*P. rubiginosa*	Rusty-spotted cat	18	0.9–1.6	65–70
EN	South Asia, Southeast Asia	*P. viverrinus*	Fishing cat	17	5.0–16.0	63–70
EN	Borneo, Sumatra, Malaya	*P. planiceps*	Flat-headed cat	14	1.5–2.5	56
		GENUS *LEOPARDUS*				
NT	Central America, South America	*L. colocolo*	Pampas cat	16	3.0–7.0	80–85
LC	North America, Central America, South America	*L. pardalis*	Ocelot	20	8.0–18.0	79–82
NT	Central America, South America	*L. wiedii*	Margay	24	2.6–4.0	76–84
VU	Central America, South America	*L. tigrinus*	Little spotted cat or oncilla	23	1.5–3.0	74–76
NT	South America	*L. geoffroyi*	Geoffroy's cat	23	2.0–5.0	72–78
VU	South America	*L. guigna*	Kodkod or guiña	14	2.0–2.5	72–78
EN	South America	*L. jacobita*	Andean mountain cat	16.5	4.0	No data
		GENUS *PUMA*				
LC	North America, Central America, South America	*P. yagouaroundi*	Jaguarundi	15	3.5–10	70–75
LC	North America, Central America, South America	*P. concolor*	Puma	24	29.0–100.0	90–96
		GENUS *NEOFELIS*				
VU	Asia	*N. diardi*	Sunda clouded leopard	11	15.0–30.0	85–95
VU	Asia	*N. nebulosa*	Clouded leopard	20	15.0–23.0	85–93
		GENUS *PANTHERA*				
EN	Asia	*P. uncial*	Snow leopard	21	25.0–75.0	90–103
EN	Asia	*P. tigris*	Tiger	26	65.0–306.0	93–112
NT	Africa, Asia	*P. pardus*	Leopard	27	23.0–91.0	90–105
NT	South America, Central America	*P. onca*	Jaguar	28	30.0–121.0	93–105
VU	Africa, Asia	*P. leo*	Lion	27	120.0–250.0	100–120
		GENUS *ACINONYX*				
VU	Africa, Middle East	*A. jubatus*	Cheetah	20	35.0–72.0	90–95

**CR*, Critically Endangered; *EN*, Endangered; *VU*, Vulnerable; *NT*, Near Threatened; LC, Least Concern.

of big cats that resonate to produce a roar. Smaller cats and cheetahs have simpler vocal folds that only allow purring.[31]

Nondomestic felids appear to have an AB blood group system similar to that described in domestic cats. Cross-matching of donor and recipients using standard techniques is important before the administration of transfusions or blood products.[36]

SPECIAL HOUSING REQUIREMENTS

Minimum husbandry guidelines for keeping small (weighing less than 10 kg) and large felids in captivity are available through the Association of Zoos and Aquariums (AZA, www.aza.org) and include recommendations on minimum size specifications, barrier height and width, temperature, humidity, lighting, ventilation, interindividual distances, and sanitation. Additional enclosure features recommended may vary by species and include a vertical component, elevated resting platforms, a heat source, shade, logs or wooden posts to sharpen claws, a visual barrier for cats to hide behind, a den or secure area, varied topography, water features for bathing and swimming, and a shift or secondary holding area to safely move animals from their primary enclosure for cleaning, feeding, or medical procedures. To reduce the incidence of osteoarthritis and pad ulceration, large felids should not be housed for long periods on concrete. Natural substrates or platforms with some flexibility that may be cleaned and disinfected should be provided.[36]

Appropriate safety precautions must be designed into the enclosure and holding facilities to ensure employee and guest safety. These include, but are not limited to, using materials of sufficient strength, covering all openings with mesh or heavy glass, and ability to view all the cats within an enclosure from a safe position. Safety gates provide secondary containment if an animal escapes from the primary holding area. Flares, fire extinguishers, and sound generators may be placed throughout the work area to deter attacks. Keepers may be required to carry pepper spray and communication radios while working with large felids. Escape drills should be held routinely.[36]

FEEDING

The diet of wild felids varies, depending on their sizes. The large cats such as lions and tigers prey on very large mammals, with only two to three species making up the bulk of their diet. Medium-sized felids such as the puma, the snow leopard, and the leopard eat smaller prey but a larger number of different species. The small felids prey on mammals, birds, reptiles, amphibians, and insects. All wild cats hunt and kill their own prey, but some will scavenge opportunistically.[31]

Felids require a much higher proportion of protein in their diet compared with any other mammal, 12% for domestic cats compared with 4% for domestic dogs.[31] In captivity, a formal nutrition program is recommended to meet the nutritional and behavioral needs of all species. Diets should be developed on the basis of the recommendations of nutritionists such as the European Association of Zoos and Aquaria (EAZA) Nutrition Group or the Association of Zoos and Aquarium (AZA) Nutrition Advisory Group (NAG). The AZA-NAG feeding program guidelines suggest a feeding strategy that includes providing a diet that is nutritionally balanced, that reasonably stimulates natural feeding behaviors, that the animal consumes consistently, and that meets the above criteria and is practical and economical to feed. Domestic cats generally require 80 to 90 kilocalories per kilogram of body weight (BW) per day (kcal/kg/day) to meet metabolic requirements. Diet quantity needs to be altered on the basis of the animal's body condition, life stage, and environmental factors. Amounts of feed may also be based on the National Research Council recommendation of 55 to 260 kcal/$BW^{0.75}$ (Requirements for Domestic Dogs and Cats, National Research Council [NRC], 2006).

Most captive felids are fed commercial meat-based complete diets, so additional vitamin or mineral supplements, including calcium and taurine, should not be necessary. Techniques for proper thawing of frozen diets prior to feeding may be found in the U.S. Department of Agriculture (USDA) guidelines on handling of frozen and thawed meat and prey items fed to captive exotic animals (http://www.nal.usda.gov/awic/pubs/meatprey.pdf). Commercial diets may be supplemented with good-quality carcasses or whole-prey items. If muscle meats or organ meats make up the bulk of the diet, additional supplementation, including calcium, may be necessary. The majority of felids are able to handle the large concentrations of microorganisms present in raw meat. However, guidelines of appropriate bacterial concentrations in received commercial products need to be established for each institution, and commercial products should be tested on a regular basis. Bones may be offered to some species on fast days or twice weekly to promote oral health and to provide enrichment. Fresh water should be made available at all times.

The diet should be analyzed routinely for nutritional content, bacterial contamination, and the presence of foreign material. Several cases of ethylene glycol toxicity from contaminated meat have been reported. The source of the diet components also should be investigated to prevent the transmission of diseases such as spongiform encephalopathies.[36]

RESTRAINT AND HANDLING

Many felids, particularly cheetahs, leopards, lions, and tigers, may be trained to cooperate with veterinary procedures. Behaviors that are particularly helpful include shifting into transport crates, obtaining regular body weights, close visual inspection and oral examination, measurement of temperature, heart rate, and blood pressure, administration of injections or other medications, positioning for abdominal ultrasonography for pregnancy monitoring, and collecting blood or other biologic samples.

Felids less than 10 to 15 kg in body mass may be restrained safely in a net for short procedures such as administration of injections. Heavy gloves may be used, but most felids are capable of biting through them. The majority of cats are darted or confined to a small area or restraint device and hand injected. Commercial squeeze cages are available for restraining and transporting larger felids and work best when incorporated into holding facilities (LGL Animal Care Products, Inc., Bryan, TX; Research Equipment Company, Bryan, TX).[36]

ANESTHESIA

A variety of drug combinations have been used safely to induce anesthesia in felids (Table 47-2). In general, smaller species require a higher dosage of anesthetics compared with larger species on the basis of kilogram of body weight, and free-living individuals may require higher dosages compared with their captive counterparts. The drug combinations most often used include a dissociative (ketamine or tiletamine), and an α_2-agonist (xylazine, medetomidine, or dexmedetomidine), benzodiazepine (diazepam, zolazepam, or midazolam), opioid (butorphanol), or a combination of these. These drugs may be antagonized with yohimbine (0.04 to 0.3 milligram per kilogram [mg/kg], intramuscularly [IM] or intravenously [IV; slow]), atipamezole (0.1 to 0.45 mg/kg, IM), naltrexone (0.05–0.25 mg/kg, IM or IV), and flumazenil (0.01–0.02 mg/kg, IV or IM). Tiletamine and zolazepam (Telazol, Fort Dodge, Fort Dodge, IA) may be used safely in many felids but should be used with caution in tigers. Adverse reactions, including death and neurologic disease (seizures, ataxia), have been anecdotally reported; but controlled studies are lacking. Regurgitation or vomiting during induction or recovery may occur when α_2-agonists are used. Food should be withheld from adult felids for 12 to 24 hours and water for several hours prior to anesthesia to decrease the chances of regurgitation and aspiration during induction and recovery. Species-specific protocols have been reported.[5,10,18,28,29,38]

Anesthesia may be maintained with supplemental ketamine (IV or IM), propofol (IV), or inhalant anesthesia (sevoflurane, isoflurane,

TABLE 47-2

Combinations of Injectable Anesthetic Agents Used in Felids

Generic Name	Dose (mg/kg)	Route	Antagonist	Comments
Ketamine	0.2–2.0	IV or IM	N/A	Not recommended if used alone, best for supplementation or maintenance of anesthesia
Ketamine Xylazine	3.0–10.0 0.3–1.0	IM	N/A Yohimbine	May need to use higher dosages than those listed for small felids
Ketamine Medetomidine (or dexmedetomidine)	2.0–6.0 0.03–0.07 (0.015–0.035)	IM IM	N/A Atipamezole	Supplements may be needed after 45–50 minutes
Ketamine Midazolam	5.0–10.0 0.1–0.3	IM IM	N/A Flumazenil	Use in small felids or debilitated cats Flumazenil may not be necessary
Ketamine Midazolam Butorphanol	3.0–5.0 0.1–0.3 0.1–0.4	IM IM IM	N/A Flumazenil Naltrexone	Use in small felids or debilitated cats Not recommended for healthy large felids Flumazenil may not be necessary
Tiletamine Zolazepam	1.6–4.2 or up to 11.0 in small felids (combined)	IM	N/A	Prolonged recovery Use with caution in tigers Can reduce dosage by adding ketamine or medetomidine
Medetomidine (or dexmedetomidine) Butorphanol Midazolam	0.03–0.04 (0.015–0.02) 0.1–0.4 0.1–0.3		Atipamezole Naltrexone Flumazenil	Spontaneous recoveries after 40–50 minutes Supplements needed for procedures >30 minutes Flumazenil may not be necessary
Ketamine Medetomidine (or dexmedetomidine) Butorphanol Midazolam	1.0–2.0 0.03–0.04 (0.015–0.02) 0.1–0.4 0.1–0.3	IM or IV IM IM IM	N/A Atipamezole Naltrexone Flumazenil	Ketamine may also be given intravenously soon after induction May get spontaneous arousal Flumazenil may not be necessary

IV, Intravenously; *IM,* intramuscularly; *N/A,* not applicable; dosages for antagonists listed in text of chapter.

or halothane). Rapid administration or high doses of ketamine (IV) may induce seizures. Rapid administration of propofol (IV) may result in apnea. Supplemental oxygen is recommended when using injectable anesthetic agents. This may be delivered through the nares, via a face mask, or through endotracheal intubation. Endotracheal intubation is strongly recommended, especially for procedures lasting more than 30 minutes.

Additional anesthetic complications include hypoxia, hypoventilation, hyperventilation, apnea, hypotension, hypertension, bradycardia, arrhythmias, seizures, hypothermia, hyperthermia, and cardiac arrest. Arousal may occur after 40 to 50 minutes when medetomidine is used as the primary anesthetic drug in combination with low doses of ketamine or with a combination of midazolam and butorphanol. This may occur with few premonitory signs, so the clinician must be prepared by having intravenous ketamine or propofol readily available or have an inhalant anesthetic available to maintain anesthesia. A recovery crate should be available in the same room where the procedure is performed if the animal has been removed from its enclosure. This greatly improves safety if there is spontaneous arousal of the animal or a rapid recovery is needed.

VENIPUNCTURE

Venipuncture sites are similar to those of domestic felids. Blood samples may be obtained from the medial and lateral saphenous, jugular, cephalic, or femoral veins. Lateral tail veins may be accessed in larger felids and are located at the 2 o'clock and 10 o'clock positions. This is a particularly useful site if the cat is confined in a squeeze cage. Reference ranges for hematologic and biochemical values for a variety of captive felid species are provided by the International Species Information System (ISIS): Physiologic values in captive wildlife (ISIS, 2002; Apple Valley, MN).

DISEASES

Felids are susceptible to many infectious and noninfectious diseases. Table 47-3 lists several felid species and the common diseases observed in captivity. Some conditions in captive animals may have a genetic predisposition or may be precipitated by chronic stress. Stress causes a reduced immune response that increases susceptibility to infectious diseases and may be associated with noninfectious diseases such as gastritis and AA-amyloidosis in cheetahs. Stress also has an adverse effect on reproduction and results in a higher tendency for self-mutilation or overgrooming.[33] Treatment modalities for the diseases below may be extrapolated from domestic feline medicine.

Infectious Diseases

Felids are susceptible to the same infections carried by domestic cats. They are also susceptible to diseases transmitted by other animals, for example, viral diseases such as canine distemper, rabies, and avian influenza; bacterial infections that cause tularemia (caused by *Francisella tularensis*) or tuberculosis (caused by *Mycobacterium bovis*); and protozoal diseases such as toxoplasmosis (caused by *Toxoplasma gondii*).[6,7,9,16,22,35] Many infections are zoonotic; therefore, good hygiene practices are essential when working with felids. It is also very important to limit exposure of captive felids to feral and domestic cats and dogs, free-living carnivores, bats, rodents, and other small mammals. The common viral diseases in felids are summarized in Table 47-4. *Helicobacter* gastritis may be a significant bacterial infection that results in regurgitation, vomiting, weight loss, and ill thrift. Although all felids may be affected, the clinical disease is most often observed in cheetahs. Management of this condition is well documented in the literature. Additional bacterial diseases include those caused by *Mycoplasma* spp. and *Chlamydophila psittaci*, which are part of the feline respiratory disease complex, and

TABLE 47-3

Common Diseases for Select Species*

Species	Common Infectious Diseases	Common Noninfectious Diseases
Lion	—	Biliary cysts or tumors Spondylosis Lymphoma Pyometra
Tiger	—	Biliary cysts or tumors Spondylosis Chronic renal disease
Jaguar	—	Ovarian and mammary cancer
Clouded leopard	—	Neoplasia especially pheochromocytomas
Cheetah	*Helicobacter* gastritis Herpesvirus dermatitis	Renal secondary amyloidosis Glomerulosclerosis Veno-occlusive disease
Snow leopard	Papillomavirus associated squamous cell carcinoma	Veno-occlusive disease
Fishing cat	—	Transitional cell carcinoma
Black-footed cat	—	Renal amyloidosis, gastrointestinal amyloidosis, or both
Pallas' cat	Toxoplasmosis Herpesvirus infection	—

*K. Terio, unpublished data.

enterocolitis caused by *Campylobacter* spp. *Salmonella* spp. may cause disease but is often passed in the feces of asymptomatic animals secondary to a raw food diet. All felids are susceptible to infections by dermatophytes, especially *Microsporum canis* and *M. gypseum*. Treatment with griseofulvin resulted in toxicity with bone marrow suppression and death in cheetahs.[36] Coccidioidomycosis (caused by *Coccidioides immitis*) has been reported in nondomestic felids in regions of the world where this pathogenic fungus resides in the soil (southwestern United States and northern Mexico). Bovine spongiform encephalopathy (BSE) has been reported in felids in Europe.[27] The cats had been fed cattle carcasses or animal products, including blood and bone meal produced in BSE endemic areas.

Significant protozoal infections include coccidiosis (caused by *Eimeria* spp.) and giardiasis (caused by *Giardia* spp.). These may result in severe enteritis, especially in kittens. Many healthy felids are seropositive for *Toxoplasma gondii* antibodies. Kittens and immunocompromised animals may develop acute generalized toxoplasmosis. High neonatal mortality in Pallas' cats from toxoplasmosis has hampered conservation efforts. Prophylactic treatment of breeding animals and neonates is recommended. *Cytauxzoon felis* is a protozoan that infects blood cells.[4,12,24,41] It is transmitted by the lone star tick (*Amblyomma americanum*). The natural reservoir is the bobcat that becomes a persistent carrier after developing mild or subclinical infection. The disease may be fatal in untreated domestic cats, and a fatal infection in a white tiger has been reported. *Babesia felis*, originally identified in wild cats from Sudan, has been reported sporadically from various countries.[1,4,20,24,41] South Africa appears to be the only country where feline babesiosis is a significant clinical entity. The infection is assumed to be tickborne, but the vector has not been identified. Concurrent infections may contribute to clinical disease. Ascarids (*Toxocara* and *Toxascaris*) are common in captive animals and may be difficult to eliminate. The ova are highly resistant in the environment. Repeated testing and treatment of animals while in quarantine may prevent the introduction of ascarids into exhibits. In chronically infected cats, routine treatment may be needed to limit worm burdens. Disease caused by *Dirofilaria immitis* (heartworm) has been diagnosed in a black-footed cat.[8] Prophylactic treatment is recommended in endemic areas.

Noninfectious Diseases

Noninfectious diseases are often related to husbandry, diet, or breeding management. Obesity is a significant cause of morbidity in captive felids and may predispose to metabolic conditions such as diabetes mellitus. "Stargazing" has been associated with hypovitaminosis A in young lions.[39] Common dental diseases include gingivitis, calculus accumulation, fractured canines, and fractured molars. Focal palantine erosions have been reported in 15 wild and captive species but is more prevalent in captive animals.[42] Degenerative joint disease and spondylosis are common in geriatric felids, especially the larger species.[19] Chronic renal failure is common in geriatric felids.[37] Renal amyloidosis is particularly common in black-footed cats and cheetahs.[34] Veno-occlusive disease is a slowly progressive liver disease, which results in the fibrosis of the hepatic sinusoids or veins and eventually occlusion of the vessels. It has been reported in cheetahs and snow leopards. Myelopathy has been diagnosed in cheetahs in Europe, and leukoencephalopathy has been diagnosed in cheetahs in North America.[27] Pyometra has been reported in lions, tigers, and a leopard.[21] Lions seem to be at an increased risk for developing pyometra compared with other species. Ovariohysterectomy may be warranted in nonbreeding female lions. The use of progestin-based contraceptives has been associated with endometrial hyperplasia and uterine and mammary adenocarcinoma. Nonsteroidal anti-inflammatory drugs (NSAIDs) should be used cautiously. Aspirin, acetaminophen, and ibuprofen may cause toxicity, and caution is advised when using other formulations such as carprofen, deracoxib, naproxen, etodolac, and indomethacin. Meloxicam has been used in nondomestic felids with no reported adverse effects.[25] Barbiturate and thiafentanil toxicity has been reported in felids fed carcasses of animals that had been euthanized or anesthetized with these agents.

REPRODUCTION

Felidae exhibit a high degree of variability in estrus cycle characteristics, including duration. All felids have induced ovulations, but some have spontaneous ovulations. The occurrence varies across species and between individuals within a species. It occurs frequently in clouded leopards, fishing cats, and margays but rarely in cheetahs, tigrinas, and ocelots. Pallas' cats are very sensitive to photoperiod; tigers, clouded leopards, and snow leopards are moderately affected; and ocelots, tigrinas, margays, lions, leopards, and fishing cats are not influenced by photoperiod. Clouded leopards and Pallas' cats exhibit seasonality in gonadal activity, but margays, cheetahs, and oncillas cycle year round. Suppressed ovarian activity and estrus occurs in cats housed in a group (e.g., cheetahs). All cats have a zonal placentation.[2,3]

Many felid species do not reproduce well in captivity. Assisted reproductive techniques such as artificial insemination are important for managing zoo species.[14,32] This technique is challenged by the variable responses to ovulation induction therapies. Fecal cortisol may be measured and reflects the adrenal status and stress levels of animals managed under different husbandry conditions. These data improve the understanding of how social and environmental factors affect the well-being and reproductive fitness of animals. Contraception of felids is sometimes necessary to facilitate management needs or because of concerns over the health of the animals.

TABLE 47-4

Selected Viral Diseases of Felids

Disease	Etiology	Epizootiology	Signs	Diagnosis	Management
Feline panleukopenia virus (FPV)	Parvovirus	Highly contagious virus shed in all secretions and excretions Shed in feces up to 6 weeks after recovery Illness lasts 5–7 days Mortality is highest in cats <5 months of age	Can be subclinical Peracute cases referred to as *fading kittens* Acute cases show fever, depression, anorexia, and dehydration Vomiting and diarrhea may be present	Presumptive diagnosis based on panleukopenia Confirm by demonstrating FPV antigen in feces Test kits for canine parvovirus antigen may detect FPV antigen during the acute phase	Virus is resistant to inactivation Can survive >1 year in a suitable environment Virus is inactivated by 6% household bleach (sodium hypochlorite) Vaccination using inactivated or killed virus recommended Late pregnancy booster with killed vaccine recommended for cheetahs
Feline rhinotracheitis or feline herpes virus (FHV)	Feline herpesvirus I	Highly contagious Virus shed in saliva and ocular and nasal secretions Easily spread by fomites High morbidity, low mortality Cheetahs and Pallas' cats very susceptible Often self-limiting and may resolve in 14–28 days Can have co-infections with calicivirus, *Chlamydophila psittaci*, *Mycoplasma* spp., or both	Serous ocular discharge, conjunctivitis, blepharospasm, sneezing, and nasal discharge Secondary bacterial infections may occur Keratitis may be seen, especially in kittens Ulcerative dermatitis is common in cheetahs Kittens may develop acute severe infections that lead to blindness or pneumonia	Presumptive diagnosis based on clinical signs, especially in cheetahs[40] Swabs of conjunctiva, nasal, or oropharyngeal region for viral isolation (VI), polymerase chain reaction (PCR), or fluorescent antibody (FA) Immunohistochemical staining (IHC) or VI of tissues	Skin lesions may respond to cryotherapy Use of modified-live virus vaccines may induce the disease in nondomestic felids Only killed vaccines should be used Vaccination will not prevent infection but may decrease severity Cats may become chronic carriers with intermittent shedding of virus Virus viable in environment for 72 hours after a shedding animal has been removed
Feline calicivirus (FCV)	Calicivirus[13]	Highly contagious Virus is shed in saliva and ocular and nasal secretions Can also be spread by fomites High morbidity, variable mortality Uncomplicated cases may resolve within 2 weeks Can have co-infections with herpesvirus, *Chlamydophila psittaci*, *Mycoplasma* spp., or both	Sneezing, ocular and nasal discharge, and oral ulcers of the gingiva and tongue Can have pulmonary involvement Secondary bacterial infections	Oropharyngeal and conjunctival swabs of lesions for VI or real time reverse transcriptase PCR (qRT-PCR) Affected tissues for VI, qRT-PCR, IHC, or FA	Use of modified-live virus vaccines may induce the disease in nondomestic felids Only killed vaccines should be used Vaccination will not prevent infection but may decrease severity Virus may survive up to 14 days on inanimate objects Recovered animals may shed virus for months to years

Feline coronavirus (FCoV) has two forms: feline enteric coronavirus (FeCV), which infects the intestines, and the fatal feline infectious peritonitis virus (FIPV), which causes the disease feline infectious peritonitis (FIP)	Coronavirus group 1	Highly contagious among cats in close contact Shed in feces of healthy cats Shedding frequency varies from rare, intermittent, or persistent (best documented in cheetahs) Also reported in domestic cats, African lion, mountain lion, leopard, lynx, jaguar, European wildcat, sand cat, serval, caracal, and Pallas' cat Transmitted by the fecal–oral route through direct contact or by fomites Signs of FeCV can last 2–5 days The more severe FIP form is fatal Most deaths in domestic cats 3–16 months of age, uncommon after 5 years	FeCV may be subclinical or may result in mild diarrhea that may be chronic Signs of FIP are fever, vomiting, diarrhea, and modified transudate effusions with high protein content. Development of FIP depends on two host factors: virus mutation and low immunity FIP is not considered directly transmissible from cat to cat but outbreaks with increased mortality from FIV do occur in groups of unrelated domestic cats in shelters and catteries	Shedding is detected by PCR of feces (three samples a month apart recommended for domestic cats, 5 samples within 30 days for cheetahs)[11] Serologic tests do not differentiate between the two forms of the disease Titers >1 : 1600–3200 are suggestive of FIP False-positive titers may result in cats recently vaccinated (<4 months) Antibody testing is only useful as a screening tool to detect presence or absence of virus in a collection, recognize potential carriers or shedders when introducing new cats into an antibody-negative collection, and as an aid in the clinical diagnosis of FIP IHC on effusions or lesions is the current gold standard for FIP diagnosis	Cats that recover remain carriers Prevention is by limiting exposure to infected cats and their feces Most cats develop an immune response when exposed and recover Vaccination results in variable efficacy and is not sufficient to control outbreaks of FIP Virus is readily inactivated by detergents and disinfectants but may survive up to 2 months in a dry environment
Feline immunodeficiency virus (FIV)	Lentivirus	Virus shed in saliva. Primary mode of transmission is bites More prevalent in males Most infections reported in older captive animals Reported in free-living puma and bobcats Endemic in certain lion populations in eastern and southern Africa	Most often asymptomatic in nondomestic felids, but may include oral cavity disease, anemia, skin infections, weight loss, vomiting, diarrhea, or neurologic disease	Presence of serum antibodies (Western blot or enzyme-linked immunosorbent assay [ELISA]) Western blot available for domestic cats, cougars, and African lions and may be more sensitive than domestic cat FIV based ELISA Isolation of virus from blood cells and saliva PCR developed for lions	Routine testing recommended Segregate positive cats Infection is lifelong Vaccination available, but may not be necessary if able to prevent exposure to feral cats FIV is labile outside the host and is readily inactivated by common disinfectants
Feline leukemia virus (FeLV)	Retrovirus	Virus may be found in saliva, tears, urine, semen, vaginal fluids, and feces Oronasal contact with saliva or urine is the most common mode of transmission Vertical transmission possible Transmitted to nondomestic cats by contact with or ingestion of domestic feral cats Persistently viremic cats develop fatal diseases Reported in cheetah, Iberian lynx, leopard cat, European wildcat, and cougar	Typically asymptomatic and transient in nondomestic felids Infected cats may experience a prolonged period of clinical latency Immunosuppression, anemia, chronic inflammatory conditions, enlarged lymph nodes, secondary infections, persistent fever, lymphoid or myeloid tumors, or reproductive problems Progressive infection or regressive infection are the outcomes reported in domestic cats	Serologic antigen tests available include immunofluorescent antibody (IFA) or ELISA, false-positives and false-negatives occur Confirmatory test with VI or real time PCR (qPCR) (blood, bone marrow, and tissues)	Routine testing recommended Segregate positive cats Some cats are able to clear the virus, but others remain persistently viremic Vaccination available, but may not be necessary if able to prevent exposure to feral cats Virus unstable outside host, but may survive for up to a week in dried biologic deposits Virus inactivated by detergents and common disinfectants

Continued

TABLE 47-4

Selected Viral Diseases of Felids—cont'd

Disease	Etiology	Epizootiology	Signs	Diagnosis	Management
Feline papillomavirus	Papillomavirus	Species and site-specific infections Reported in domestic cats, Asian lion, bobcats, Florida panther, clouded leopard, Canadian lynx, and snow leopards[15,30]	Proliferative lesions in the skin or oral cavity Papillomas in snow leopards may undergo malignant transformation to squamous cell carcinoma	PCR of excised lesion developed for snow leopards	Routine screening for skin and oral lesions Remove using surgical excision, laser surgery, or cryosurgery and prevent virus from contacting adjacent tissue Vaccine for snow leopards under development
Canine distemper virus (CDV)	Morbillivirus	Highly contagious Aerosolization of respiratory exudate or contact with other body excretions and secretions Vaccine-induced disease using modified-live virus reported in other carnivores but not felids Not all felids develop disease Mortality reported in captive lions, tigers, leopards, and a jaguar and in free-living lions, lynx (Canadian and Iberian), and bobcats	Infections may be subclinical or fatal. Respiratory, gastrointestinal, integumentary, and central nervous system signs Hyperkeratosis of foot pads and myoclonus	Immunoflourescence of conjunctival scrapings, or buffy coat smears Paired sera by viral neutralization or IFA test. ELISA may detect immunoglobulin G (IgG) and IgM. Antibodies in cerebrospinal fluid (CSF) may be more rewarding than serum Viral isolation, qRT-PCR, or IHC of tissues	Exclude potential reservoirs (domestic dogs, raccoons) Vaccinate susceptible felids using recombinant vaccine
Rabies virus	Lyssavirus	Bites of infected animals (carnivores or bats) Contact of saliva with mucous membranes or open wounds Aerosol in an enclosed environment Fatal disease within 2–7 days of illness	Salivation, abnormal behavior (aggression) or neurologic signs (paresis, seizures)	Recommend euthanasia and shipment of head to a qualified laboratory for FA or VI Serology used to monitor response to vaccination	Reportable disease Zoonotic disease Vaccination recommended Limit exposure to wild carnivores and bats Lyssaviruses are not stable in the environment and are inactivated by common disinfectants
Avian influenza (AI)	Type A influenza virus, subtype H5N1, further classified as highly pathogenic (HPIA) or low pathogenic (LPAI) according to its virulence in poultry	Transmission occurs through the respiratory and oral routes Reported in domestic cats, tigers, leopards, and Asiatic golden cats Direct contact with affected birds or were fed raw poultry Cat-to-cat transmission has been documented	Fever, respiratory distress, severe pneumonia, rapid death Neurologic signs (circling, ataxia) may be observed Subclinical infections also occur	Oropharyngeal, nasal and/or rectal swabs or fecal samples for RT-PCR and/or VI Postmortem samples of lung and mediastinal lymph nodes for VI or RT-PCR	Reportable disease Zoonotic disease Each institution should have a highly pathogenic avian influenza (HPAI) preparedness protocol Do not feed poultry products to nondomestic felids especially in countries with known or potential outbreaks Virus is sensitive to standard disinfectants Virus may persist in cool aquatic environments (>100 days) or indefinitely if frozen

The AZA Wildlife Contraception Center (2012) makes the following recommendations for felid contraception:

1. Gonadotropin-releasing hormone (GnRH) agonists are considered the safest reversible contraceptives, but dosages and duration of efficacy are not well established for all species (caution has to be exercised in their use in lions because of prolonged response with questionable reversibility at certain doses). Side effects are generally similar to those associated with gonadectomy, especially the potential for weight gain.
   - Suprelorin (deslorelin) implants (female or male)
   - Lupron® Depot injection (female or male)
2. Ovariohysterectomy or ovariectomy (females) or castration (males) may be considered if permanent sterilization is an option.
3. In felids, progestin contraceptives are associated with progressive uterine growth that may result in infertility, infections, and sometimes uterine cancer; mammary tissue stimulation may result in cancer. If a progestin is used, treatment should only be short term and should be started before any signs of proestrus. Progestins should not be used in pregnant animals.

PREVENTIVE MEDICINE

Routine Health Examination

Routine, periodic, or opportunistic health examinations should be part of the preventive medicine protocol for felids. Many institutions perform examinations under anesthesia every 2 to 4 years, but this frequency is dependent on the individual animal's age, life stage, health status and medical history, and species and the resources and philosophy of the holding institution. Animals that are trained as part of an operant conditioning program may be visually examined, have blood collected, and receive vaccinations without anesthesia or the need for remote delivery equipment. These examinations may be substituted for one under anesthesia in many cases if dental examination and prophylaxis and thorough palpation are deemed unnecessary. Routine health examination should include an assessment of body condition, body weight determination, complete physical examination, evaluation for ectoparasites (ticks, fleas, flies), blood collection for complete blood cell (CBC) count with manual differential and hemoparasite examination, serum biochemical panel, and serum for banking. Recommended serologic tests include those for feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV). Additional tests that may be necessary based on species, geographic location, or potential for disease exposure include those for *Toxoplasma gondii,* feline coronavirus (FCoV), and canine heartworm (*Dirofilaria immitis*). Serologic tests to monitor response to vaccination may be useful for feline parvovirus (FPV), especially in cheetahs, and for the rabies virus.[26] Vaccine titers for feline herpesvirus (FHV) or feline calicivirus (FCV) are predictive of protection, except for highly susceptible species such as cheetahs. If a cheetah has a low or negative titer to FPV or FHV, more frequent vaccination should be considered. Urinalysis should be performed, if possible. Survey radiography and abdominal ultrasonography may be valuable if resources are available to establish reference information or to diagnose occult conditions. Fecal examination for parasites is recommended at this time if a regular program for parasite surveillance (once to twice yearly) is not already in place.

Vaccination

Vaccination protocols for carnivores have been recently reviewed.[17] Vaccines recommended are divided into core vaccines (recommended for all felids) and noncore vaccines (optional, depending on the specific disease risk of the species and institution, not generally recommended). Vaccine-associated sarcomas have rarely been reported in nondomestic felids. Because of the lack of serologic studies and difficulty in performing challenge experiments on nondomestic felids, specific information on the length of protection from vaccination is lacking. Specific recommendations for vaccination frequency cannot be made, although most institutions vaccinate adults every 1 to 3 years using the core vaccines. Core vaccines include rabies (killed, e.g., Imrab 3, Merial; or recombinant canarypox-vectored, e.g., PureVax Rabies, Merial) and feline panleukopenia, calicivirus, herpesvirus (killed, e.g., Fel-O-Vax PCT Plus, Boehringer Ingelheim). Noncore vaccines that should be considered only in species at risk include canine distemper virus (CDV) (recombinant canarypox-vectored, PureVax Ferret Distemper, Merial) and FeLV (killed).

Preshipment Evaluation and Quarantine

Animals that are being shipped to a new institution should be evaluated using the procedures described earlier. The preshipment examination and test results allow the receiving institution to discuss disease risks associated with the acquisition in advance with animal managers. Results should be compared with the results of the quarantine examination at the receiving institution. Examination and testing during the quarantine period provides vital information following the stress of shipment and change in environment. Biologic samples should be stored for future testing or studies, as needed.

Quarantine should occur in an off-exhibit area away from other animals, especially other carnivores (collection and free-living). Dedicated tools and equipment and personal protective equipment (removable outer wear, gloves) should be used. If dedicated footwear is not an option, a footbath may be used. Quarantine period for all felid species is typically 30 days, but this may vary depending on the source of the cat or institutional practices.

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