CHAPTER 46

Canidae

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GENERAL BIOLOGY

The family Canidae currently includes 35 species of dogs, wolves, coyotes, jackals and foxes[39] (Table 46-1), and a larger number of subspecies whose status is under constant revision. All members are part of the subfamily Caninae, which is the only extant group of three subfamilies in the fossil record of this family. Evidence suggests that the Eastern wolf should be considered a distinct wolf species (*Canis lycaon*) that is more closely related to the red wolf (*C. rufus*) than to the gray wolf of which it has been historically considered a subspecies (*C. lupus lycaon*).[21] The most common canid, the domestic dog, derived from the gray wolf (*C. lupus*) through close association and interactions with humans approximately 12,000 years ago. The dingo and the New Guinea singing dog are considered feral populations of domestic dogs that have reverted to a wild status and are thus considered subspecies of *C. lupus*.

Canidae is one of the most geographically widespread carnivore families; at least one wild species is present on each continent, except Antarctica. The red fox, which is present on five continents, and the gray wolf, present on three, span some of the largest geographic ranges of any terrestrial mammal. Canids have diversified to inhabit a wide variety of habitat types. Species occur in desert environments, savannas, tropical and temperate forests, coastal areas, and arctic environments. Individual species range in size from members of the *Vulpes* genus weighing 1 kilogram (kg) or less, to subspecies of the gray wolf exceeding 60 kg. Sexual dimorphism occurs in a majority of species, and males are typically larger. Some species are solitary, some form monogamous or seasonally monogamous pairs, whereas others have large, complex packs of multiple generations within a social unit. Large packs of some species make formidable and efficient units capable of preying on larger animals and fending off predators. Many smaller canids forage for prey alone, in pairs, or in small groups. Some species such as the coyote (*C. latrans*) exhibit extreme social flexibility, being capable of existing as solitary individuals, in pairs, or in large complex packs.

A large proportion of the recognized wild canid species currently face the threat of extinction,[39] and numerous subspecies are at risk even when the species may be stable as a whole. Many populations have been extirpated from portions of their historic range. Persecution by humans, the introduction of diseases from domestic dogs, habitat disturbance, and hybridization with domestic or wild canids pose significant threats to the continued survival of many species. At least one species (the Falkland Island wolf, *Dusicyon australis*) has become extinct within the last 150 years (in 1876) as a result of direct human pressure.

UNIQUE ANATOMIC FEATURES

Canids exhibit characteristic skull features, including the medial position of the internal carotid artery between the entotympanic and petrosal arteries, loss of the stapedial artery, and an inflated entotympanic bulla divided by a partial septum. The insertion point of the digastric muscle is widened in several canid taxa, forming a subangular lobe on the horizontal ramus of the mandible, which has been

TABLE 46-1

Canid Species and Population Status[39]

Common Name	Latin Name (Number of Subspecies)	Adult Weight Range (kg)	Status / Population Trend (IUCN Red List)*
Bat-eared fox	*Otocyon megalotis* (2)	3.2–5.4	Least Concern / Unknown
Raccoon dog	*Nyctereutes procyonoides* (6)	2.9–12	Least Concern / Stable
Channel Island fox	*Urocyon littoralis*	1.4–2.5	Critically Endangered / Decreasing
Gray fox	*Urocyon cinereoargenteus* (16)	2–5.5	Least Concern / Stable
Arctic fox	*Alopex lagopus*	2.4–5.4	Least Concern/ Stable
Indian fox	*Vulpes bengalensis*	1.8–3.2	Least Concern / Decreasing
Blanford's fox	*Vulpes cana*	0.8–1.5	Least Concern / Unknown
Cape fox	*Vulpes chama*	2–4.2	Least Concern / Stable
Corsac fox	*Vulpes corsac*	1.6–3.2	Least Concern / Unknown
Tibetan fox	*Vulpes ferrilata*	3–4.6	Least Concern / Unknown
Kit fox	*Vulpes macrotis* (8)	1.6–2.7	Least Concern / Decreasing
Red fox	*Vulpes vulpes*	3.6–8.7	Least Concern / Stable
Swift fox	*Vulpes velox*	1.6–2.5	Least Concern / Stable
Ruppell's fox	*Vulpes rueppelli*	1–2.3	Least Concern / Unknown
Pale fox	*Vulpes pallida* (5)	2–3.6	Least Concern / Unknown
Fennec fox	*Vulpes zerda*	0.8–1.9	Least Concern / Unknown
Dhole	*Cuon alpinus* (9–11)	10–20	Endangered / Decreasing
Side-striped jackal	*Canis adustus*	7.3–12	Least concern / Stable
Golden jackal	*Canis aureus*	6.5–9.8	Least Concern / Increasing
Black-backed jackal	*Canis mesomelas* (6)	5.9–12	Least Concern / Stable
Coyote	*Canis latrans* (19)	7.7–16	Least Concern / Increasing
Gray wolf	*Canis lupus* (13)	20–60†	Least Concern / Stable‡
Red wolf	*Canis rufus*	20–35	Critically Endangered / Increasing
Ethiopian wolf	*Canis simensis*	11–20	Endangered / Decreasing
African wild dog	*Lycaon pictus*	19–35	Endangered / Decreasing
Maned wolf	*Chrysocyon brachyurus*	18–32	Near threatened / Unknown
Bushdog	*Speothos venaticus*	5–8	Threatened / Decreasing
Short-eared dog	*Atelocynus microtis*	9–10	Near Threatened / Declining
Culpeo (Andean fox)	*Pseudalopex culpaeus* (6)	4–11	Least Concern / Stable
Darwin's fox	*Pseudalopex fulvipes*	2–4	Critically Endangered / Decreasing
Chilla	*Pseudalopex griseus* (4)	2.5–5	Least Concern / Stable
Pampas fox	*Pseudalopex gymnocercus* (3)	4.2–5.9	Least Concern / Increasing
Sechuran Desert fox	*Pseudalopex sechurae*	2.6–4.2	Near Threatened / Unknown
Hoary fox	*Pseudalopex veturus*	2.5–4	Least Concern / Unknown
Crab-eating fox	*Cerdocyon thous*	5–7	Least Concern / Stable

*International Union for the Conservation of Nature: *IUCN Red List of Threatened Species. Version 2012.2*. www.iucnredlist.org. Accessed February 1, 2013.
†Significant size variation occurs between subspecies of *Canis lupus*.
‡Status reflects species as a whole; the status of individual subspecies is at varying risks of extinction, and populations are not stable.

hypothesized to be a functional adaptation for rapid jaw movement.[3] The subangular lobe is prominent in foxes with complex molars, including the genera *Urocyon*, *Otocyon*, and *Cerdocyon*, and in raccoon dogs (*Nyctereutes* spp.).[42] The dental formula of Canidae is incisors (I) 3/3, canines (C) 1/1, premolars (P) 4/4, molars (M) 2/2 in all but three genera (*Speothos*, *Cuon*, and *Otocyon*). Although not unique among carnivores, the maxillary fourth premolar and the mandibular first molar of canids are modified to oppose each other and maximize the shearing efficiency when biting into prey. The modified teeth are termed *carnassial* or *sectorial teeth*.

Specialized lateral nasal glands provide moisture for evaporative cooling during panting, which is the primary heat loss mechanism in canids. Sweat glands are only present in the footpads and are not significant to heat dissipation. Cutaneous muscles may control the pelage and serve an important thermoregulatory role. Seasonal molt of the pelage of temperate species is an important adaptation to coping with temperature extremes. Canids have four digits in each of the hindlimbs and five in each of the forelimbs, although the first digit may be rudimentary. The African wild dog (*Lycaon pictus)* is the exception, with only four digits on each limb.

Many of the larger canids are adapted for traveling long distances as they forage or chase prey, and during seasonal migrations. These species have significant aerobic and anaerobic capabilities for running at high speeds over long distances while chasing prey. Canids have refined senses of hearing, smell, and vision, which are key to maintenance of complex social systems, communication between conspecifics, and maintaining territories. Olfactory cues from urine, feces, and anal and supracaudal glands have an important role in canid social interactions.

The supracaudal gland, commonly called the *tail gland* or the *violet gland* because of its production of volatile terpenes similar to those produced by flowers in the Violaceae family, is a specialized scent gland located on the dorsal surface of the tail. The tail gland is located at the level of the seventh to ninth caudal vertebrae and is most developed in solitary fox species (such as Artic, red, and corsac foxes), less developed in jackals,[38] and absent in African wild dogs.[18] Powerful hair erector muscles associated with the tail gland contract to release a lipoprotein onto the surface of the skin,[38] which plays a role in species and individual recognition.

The raccoon dog (*N. procyonoides*) and other species may undergo a period of seasonal torpor or hibernation, characterized by decreased basal metabolic rates and lower levels of cortisol, insulin, and thyroid hormones.[23] The African wild dog lacks variation at the major histocompatibility complex (MHC), which is a fundamental component of the immune response of all vertebrate species and may be the result of population bottlenecks experienced by this species.[24]

SPECIAL HOUSING REQUIREMENTS

In a family with a broad range of body sizes, occupying all possible habitats and maintaining a diversity of social systems, it is nearly impossible to standardize the ideal housing requirements for all species. Guidelines for captive housing space have been established for most canid species by the Association of Zoos and Aquariums.[35] An ideal enclosure takes into account overall holding area, size of the social group being housed, reproductive status of the group, and complexity of the area to elicit and maintain species-appropriate behaviors. The shape of an enclosure must allow animals to fully use the space, allow for proper interindividual distances, and provide flexibility in managing social groups, whose hierarchy and dynamics may change over time. Complex environmental features in enclosures stimulate the natural display of species-appropriate behaviors and likely minimize stress levels. Features in enclosures should allow for social species housed in groups to separate themselves, as needed, in cases of aggression and for packs to display a healthy behavioral repertoire. Gunnite and concrete wall enclosures may create undesirable acoustics that may be disturbing to many canids. Visual barriers and natural plantings provide cover and shade and also serve to muffle unwanted sounds.

Enclosures should not have sharp corners, as these may facilitate upward propulsion and climbing. Animals running along a fence line may reach a corner and may jump upward and fall or do back flips, often injuring themselves. Sharp corners may be difficult for individuals to maneuver when running and may result in traumatic injuries to the skull, face, or neck. Spiral hindlimb fractures occurring in wolves jumping straight up in a corner and landing on one leg have been documented. Additionally, sharp corners may create conditions that provide a subordinate or incompatible individual with no means of escaping an aggressor.

Enclosures should incorporate a holding space and additional holding areas for temporary holding or transfer. For large canids, where single-sex group of two animals or a nonbreeding pair is housed, the primary enclosure should be 5000 square feet (465 square meters [m^2]), and an additional 1000 square feet (93 m^2) per additional animal.[35] Maned wolves (*Chrysocyon brachyurus*) in this social setting require more space (10,000 square feet [930 m^2]). Enclosures housing two large canids or a nonreproductive pair should have at least two holding pens of 200 square feet (19 m^2) each.[35]

Large canids housed as a single generation per breeding enclosure should have 10,000 square feet (930 m^2) and at least three holding pens of 200 square feet (19 m^2) each.[35] Enclosures intended to serve as multigenerational breeding areas need a minimum of 10,000 square feet (930 m^2), plus a secondary enclosure of 5000 square feet (465 m^2) and at least three holding pens of 200 square feet (19 m^2) each. Enclosures holding groups for potential reintroduction to the wild need larger areas (20,000 square feet [1,860 m^2]) plus a secondary enclosure of 5000 square feet (465 m^2), and at least three holding pens of 200 square feet (19 m^2) each, and special attention must be paid to the management practices and location of the enclosures to maintain wild behaviors and avoid imprinting on humans.[35]

Minimum space recommendations for small canids vary by species and social structure. Primary enclosure areas should be at least 6.5 feet (ft.) × 6.5 ft. × 5 ft. tall (2 m × 2 m × 1.5 m) for one or two animals, 10 ft. × 10 ft. × 5 ft. tall (3 m × 3 m × 1.5 m) for three animals, and 13 ft. × 13 ft. × 5 ft. tall (4 m × 4 m × 2 m) for family groups with up to five offspring. These guidelines are currently under revision, but these dimensions should be exceeded, whenever possible, and attention paid to the space layout, complexity, and social needs of the species. Minimum housing guidelines set for domestic dogs by the Animal Welfare Act of the U.S. Department of Agriculture (USDA), section 3.6(c)(1), are not sufficient for all wild canids and should be exceeded.

Canids are proficient diggers and skilled jumpers. When fences are used, fence posts should be buried properly to secure them. These "dig barriers" should be 6 to 12 inches underground and extend 3 feet toward the center of the enclosure to prevent a prolific digger from tunneling under it.[35] Buried concrete barriers may be used underground instead of fencing. Enclosure perimeter barriers should be of appropriate height to prevent an animal from jumping over, and the top could be angled or covered to discourage animals from obtaining footing on the wall and propelling themselves upward. A containment height of 8 ft. is recommended for most large canids as long as the surface does not allow climbing.

Many species may tolerate a wide range of ambient temperatures, but small canids may be less tolerant of temperature extremes when housed outside of their natural climate and require special attention. Tropical species such as maned wolves, bushdogs, and African wild dogs are less tolerant of cold temperatures compared with temperate species of similar size. Species housed outdoors should have access to dry den structures and bedding, as well as shelters that individuals may choose to use for protection from the wind or rain. A periparturient dam should have multiple choices of warm and dry whelping boxes, and attention should be paid to the breeding season and the time of year, as some species will give birth during the colder months in temperate areas.

FEEDING

The diets of wild canids range from omnivory to strict carnivory, and some species consume primarily insectivorous or piscivorous diets. Bushdogs (*Speothos venaticus*), dholes (*Cuon alpinus*), and African wild dogs are highly carnivorous, whereas bat-eared foxes (*Otocyon megalotis*) are almost exclusively insectivorous in the wild. The Ethiopian wolf (*Canis simensis*) is adapted to a diet that is based almost exclusively on rodents, and maned wolves are the most omnivorous of the large canids. The proportion of dietary components varies seasonally among omnivorous species, depending on prey or plant abundance and the breeding season.

The daily caloric need of a large canid (22–32 kg) has been estimated at 1300 to 1800 kilocalories (kcal) metabolizable energy (ME) per day in a thermoneutral environment under moderate activity.[35] Caloric needs should be adjusted on the basis of the life stage of the animal, activity and thermoregulatory needs, and body condition. As a general guideline, the daily ME requirements of adult domestic dogs have been estimated at 50 to 65 kcal/kg of body weight, approximately 120 kcal/kg for growing puppies, 200 kcal/kg for lactating females, and as high as 450 kcal/kg for heavy working dogs.

Canid diets typically contain 20% to 28% protein, 5% to 18% fat, and 2% to 4% crude fiber.[35] This formula is derived from domestic dog requirements. Although it is recognized that species-specific differences exist with regard to some of these needs, objective information is lacking for most species' needs. Canine diets based on raw meat are commercially available and form the basis of captive diets for some species, whereas others may be maintained on dry kibble. Dietary intolerance manifested by gastrointestinal (GI) disturbances, skin reactions, poor pelage, and cachexia have been reported in individuals that are maintained on cereal-based or highly processed grain diets. Omnivorous canids probably require high amounts of dietary fiber and may benefit from the addition of natural fiber sources to their diet, including produce and fruit.

Whole prey items (rodents, rabbits, chickens) or partial carcasses (bones, ox tails, legs, deer) are used to supplement captive diets, but they must be taken into account when calculating overall dietary needs and should not be offered to the degree whereby they offset a balanced diet. Feeding whole or partial carcasses of wild or domestic ungulates often is used to stimulate pack behaviors and for social enrichment. Caution should be exercised to ensure that the carcasses are fresh, free of parasitic or other diseases, and harvested by using methods that do not contain harmful substances (such as lead shot, euthanasia solution, nonsteroidal anti-inflammatory drugs [NSAIDs], or toxins). Additional caution should be exercised in areas where prion diseases (such as bovine spongiform encephalopathy [BSE] or chronic wasting disease [CWD]) are present, since carnivore species may be susceptible to prion-associated neurologic disease. The USDA Animal Welfare Act (Section 13, 9 CFR, Subsection F, Section 3.129) specifically discourages feeding roadkill to large felids but outlines guidelines for proper handling if it must be fed. The same guidelines are applicable to canids. If whole carcasses are fed to animals intended for reintroduction, only carcasses from natural prey species should be offered, and domestic animal carcasses should never be offered, as canids will likely learn to recognize the species offered as possible prey items.[35]

It has been suggested that the maned wolf has lower animal protein needs compared with other canids.[35] Scat studies of wild maned wolves suggest that plant material may account for 50% of their diet, with small mammals, insects, and birds accounting for the rest.[8] Taurine levels should be monitored in captive maned wolves, and supplementation may be necessary on an individual basis.[8] A soy-based pelleted diet has been commercially developed specifically for captive maned wolves, and preliminary results of experimental feeding show improved fecal consistency and body condition scores.

RESTRAINT AND HANDLING

Small canids may be restrained manually or with the use of nets. The use of leather gloves is recommended, but these do not provide full protection against significant bite injuries to a handler. A towel may be used to temporarily immobilize a small canid, and the head may be restrained through the towel by placing a hand behind the head while supporting the body with the other hand. Muzzles designed for domestic dogs may be used for handler protection when handling, and soft cloth rope or cotton roll gauze may be used as an impromptu muzzle. Muzzles must be monitored so that placement allows for normal breathing and avoidance of hyperthermia and should only be used for short periods. Canids may be conditioned for restraint in squeeze cages, and relatively simple ones may be designed and built if none is commercially available. Animals also may be trained for voluntary restraint and to accept injections.

Hyperthermia is a common phenomenon seen in restrained canids, and body temperatures reaching or exceeding 40°C (104°F) warrant intervention. Persistent or prolonged hyperthermia may have a fatal outcome and has been documented in some species, notably dholes. Treatment with intravenous cool fluids and external cooling is warranted to combat hyperthermia, but this should be done slowly and while continuing to monitor body temperature. Sedatives are indicated in the management of stress-related hyperthermia. Some canids are prone to developing exertional myopathies after prolonged restraint, and if the clinician suspects it, supportive treatment should be instituted immediately.

FIGURE 46-1 Physical restraint of an adult male Mexican gray wolf (*Canis lupus baileyi*). The individual has been prompted to enter a wooden den box with a hinged top. A restraint pole has been placed on the neck and a towel has been placed over the head while two "Y"-shaped padded poles are placed over the shoulders and hips to prevent the animal from rolling, jumping, or backing up. This mode of restraint provides safe access for limited examinations and performing minor medical procedures. (Photo courtesy of Luis R Padilla, Endangered Wolf Center, Eureka, MO.)

Maned wolves may be physically restrained.[15] Confined gray wolves and red wolves may be physically restrained by experienced crews by using "catch" poles and "Y"-shaped padded poles. A team of people may enter an enclosure and exploit these species' typical aversion to humans, forming a line and funneling the animal into either a corner of an enclosure or a den box. When approached, the animals will often cower, allowing for restraint with a catch pole placed loosely around the neck. Rigid but padded "Y"-shaped poles may be gently, but firmly, placed over the hips and shoulders to prevent an animal from jumping back or rolling while restrained by the catch pole (Figure 46-1). This type of restraint may be used for limited examinations, ultrasonography, blood collection, vaccination, or administration of intravenous injections. This technique is less effective and potentially dangerous when attempting to restrain hand-raised animals and individuals that have no aversion to humans, as they may resist restraint or attempt to attack when cornered and is not recommended for other large canid species (such as African wild dogs). Chemical restraint is recommended for prolonged or invasive procedures involving most large canids.

Trapping is a tool used for the management, relocation, and study of wild canid populations. Box traps have been successfully used for trapping wild canids and are considered more humane and less stressful than other alternatives[47] but are less effective for capturing the majority of wild canid species. Foothold traps (metal "jaw" traps and cable "noose" restraint devices)[6] are used to capture wild canids, specifically wolves, foxes, and dholes, although their use has been outlawed in some countries. Traps should be properly padded and inspected to ensure proper functioning and minimal risk to the animal. Every consideration should be made for humane usage and exclusion of nontarget species. Foothold traps may cause injuries to the feet, legs and teeth,[32] and individuals may develop hyperthermia or myopathy if restraint is prolonged. When initially restrained, some animals may actively dig and pull against the trap and may self-mutilate in trying to escape. If multiple traps are set within a short distance, an animal may be caught in more than one trap, or the mechanism may close around nontarget body parts as the animal rolls, pulls, and tries to escape from the primary restraint. The use of remote monitoring devices (e.g., motion sensors, cameras, and remote alarms that link to personal communication devices) has greatly improved the ability to minimize restraint time, and their use

TABLE 46-2

Select Injectable Anesthetic Combinations Applicable to Canid Species

Species	Suggested Combination
Arctic fox (*Alopex lagopus*)	Ketamine (2.5 mg/kg), Medetomidine (0.05 mg/kg) IM[6] Tiletamine-zolazepam (10 mg/kg) IM[6]
Golden jackals (*Canis aureus*)	Ketamine (1.8–2.4 mg/kg), medetomidine (0.09–0.11 mg/kg) IM[15] Medetomidine (0.07–0.1 mg/kg), midazolam (0.39–0.55 mg/kg) IM[15]
Coyotes (*Canis latrans*)	Ketamine (4 mg/kg), xylazine (2 mg/kg) IM[6] Ketamine (3–4 mg/kg), medetomidine (0.04–0.07 mg/kg) IM Telazol (10–11 mg/kg) IM[6]
Gray wolves (*Canis lupus*)	Ketamine (3–4 mg/kg), medetomidine (0.06–0.08 mg/kg) IM[6] Medetomidine (0.04 mg/kg), butorphanol (0.4 mg/kg), ketamine (1 mg/kg) IM Ketamine (5–10 mg/kg), midazolam (0.1–0.4 mg/kg) IV (after manual restraint) Ketamine (4–10 mg/kg), xylazine (1–3 mg/kg) IM[6] Telazol (10–13 mg/kg) IM (for helicopter captures)[6]
Red wolves (*Canis rufus*)	Ketamine (2 mg/kg), medetomidine (0.02 mg/kg), butorphanol (0.2 mg/kg) IM6 Medetomidine (0.04 mg/kg), butorphanol (0.4 mg/kg) IM, supplement with IV diazepam (0.2 mg/kg) or ketamine (1 mg/kg)[6] Telazol (5–10 mg/kg) IM[6]
Ethiopian wolves (*Canis simensis*)	Telazol (2–7 mg/kg) IM[23]
Maned wolf (*Canis brachyurus*)	Medetomidine (0.04 mg/kg), butorphanol (0.4 mg/kg) IM Dexmedetomidine (0.02 mg/kg), butorphanol (0.4 mg/kg) IM Ketamine (2.5 mg/kg), medetomidine (0.08 mg/kg) IM[23] Ketamine (6–9 mg/kg), xylazine (0.5–2 mg/kg) IM[23] Telazol (3–5 mg/kg)[23]
Dhole (*Canis alpinus*)	Telazol (2 mg/kg), ketamine (2 mg/kg) Telazol (4 mg/kg)[16]to (10 mg/kg)[6] IM
African wild dog (*Lycaon pictus*)	Medetomidine (0.04–0.06 mg/kg), butorphanol (0.18–0.3 mg/kg), midazolam (0.18–0.4 mg/kg) IM[11] Ketamine (1.5 mg/kg)[18] to (5 mg/kg)[6], medetomidine (0.04 mg/kg)[18] to 0.1 mg/kg)[6] IM Telazol (1–4 mg/kg) IM (wild animals may be more sensitive)[23]
Chilla (*Pseudalopex griseus*)	Ketamine (2.5–3.1 mg/kg), medetomidine (0.05–0.06 mg/kg) IM[1] Ketamine (9.3–17.7 mg/kg), xylazine (1.2–2.0 mg/kg) IM[1] Telazol (1.6–8 mg/kg) IM[1]
Bushdog (*Speothos venaticus*)	Ketamine (5 mg/kg), medetomidine (0.05 mg/kg) IM[7] Telazol (3 mg/kg), ketamine (3 mg/kg) IM[7] Telazol (10 mg/kg) IM[23]
Red fox (*Vulpes vulpes*)	Ketamine (4 mg/kg), medetomidine (0.02 mg/kg), butorphanol (0.04 mg/kg) IM[23] Ketamine (25–30 mg/kg), midazolam (0.6 mg/kg) IM[23] Telazol (4–10 mg/kg) IM[23]

Note: Medetomidine and dexmedetomidine should be antagonized with atipamezole. Xylazine may be antagonized with yohimbine or atipamezole.

is reccommended.[22] The use of tranquilizer trap devices has been considered for the capture of some canid species.[37]

A large number of anesthetic protocols have been used for the chemical restraint of canid species.[1,7,11,13,19,23,46] Table 46-2 summarizes some species-specific suggested anesthetic protocols, but readers should consult a more thorough source[23] for specific considerations. In addition, some of these protocols have been used extensively in other canid species despite lack of documentation in the peer-reviewed literature, and clinicians should use a solid understanding of drug mechanisms and sound judgment to extrapolate and use in appropriate situations.

Small canids may be anesthetized with gas anesthetic agents after restraint by hand or confinement in an anesthetic chamber. An injectable tiletamine–zolazepam combination is often used for canid anesthesia because of a relatively wide safety margin, although dose-dependent, prolonged, and rough recoveries are common. Combinations of ketamine with an α_2-adrenergic agonist (xylazine, medetomidine, or dexmedetomidine) have the advantage of reversibility despite concerns with spontaneous arousals and hypertension in many individuals. Variations on combinations of α_2-adrenergic agonists, opioids, and benzodiazepines provide deep sedation and immobilization and reversibility in most species, although anesthetic induction times may be longer than those seen with ketamine-based combinations.

SURGERY

Common surgical problems in nondomestic canids include the repair of lacerations or traumatic wounds, including wounds to the tongue, cheek, or teeth, and orthopedic injuries. Dehiscence of the body wall has been frequently seen after abdominal surgeries in wild canids, and some species will subsequently cannibalize their own internal organs. Good surgical technique, proper pain management, and postoperative restrictions will limit automutilation of the surgical site. Social species such as bushdogs and wild dogs may be particularly challenging, as isolation often leads to increased pacing and activity, and an animal isolated for prolonged periods may not be allowed back into a social group. Alternatively,

TABLE 46-3

Reference Ranges: Hematologic Parameters of Select Canid Species

Parameter	Gray Wolf (*C. lupus*)[18]	Maned Wolf (*C. brachyurus*)[18]	African Wild Dog (*L. pictus*)[18]	Arctic Fox (*A. lagopus*)[18]	Crab-Eating Fox (*C. thous*)[25]
Erythrocytes (× 10^6/μL)	5.72–8.36	4.47–6.37	6.84–8.86	7.7–10.1	3.05–6.08
PCV (%)	39.7–56.5	34.3–47.5	38.5–48.7	41.7–54.3	28–53
Hemoglobin (g/dL)	13.3–19.7	11.3–15.9	14.4–17.2	13.7–17.3	10–18.1
MCV (fL)	63.4–78	68.4–83.2	50.8–60.8	49.4–57.8	79.1–100
MCH (pg)	22–27	23.2–28.2	17.5–21.7	16–19.6	26.0–34.9
MCHC (g/dL)	30.5–37.3	31.1–36.1	32.8–37.2	29.6–35.6	30.2–38.5
Leukocytes (/ μL)	6,546–12,868	6,580–14,360	7,340–14,480	3,170–9,350	3,400–23,200
Neutrophils (/ μL)	4353–9719	3669–10,481	5334–11,262	1035–5333	1,460–12,990
Banded neutrophils (/ μL)	0–198	0–395	0–288	0–266	0–700
Lymphocytes (/ μL)	737–2403	1029–3343	570–2724	665–3849	210–3,990
Eosinophils (/ μL)	0–661	0–617	0–658	0–628	270–3,940
Monocytes (/ μL)	0–468	0–334	0–462	0–248	40–2,550
Basophils (/ μL)	0–55	0–79	0–99	0–194	0–520
Platelets (× 10^3/ μL)	166–336	145–285	254–626	225–467	*

*Low value of range published likely not normal based on published average of 233.27 +/– 112.63 × 10^3/μl.

fL, Femtoliters; *g/dL*, gram per deciliter; *MCH*, mean corpuscular hemoglobin; *MCHC*, mean corpuscular hemoglobin concentration; *MCV*, mean corpuscular volume; *PCV*, packed cell volume; *pg*, picogram.

reintegration into a social group too soon after a surgical procedure may lead to excessive grooming, licking, or biting at the incision site by conspecifics.

A simple interrupted pattern is the preferred method of abdominal wall closure for most wild canid species.[18] A simple continuous pattern has been advocated as a dependable, time-efficient method of closure of the rectus sheath in domestic dogs with no difference in complications when compared with a simple interrupted pattern,[20] but simple continuous closure of the body wall is not the preferred method in nondomestic canids because of concerns about rapid dehiscence if a knot fails or is chewed at by an individual. Subcuticular skin closure will discourage the grooming or scratching of external sutures.

Cystotomy may be necessary for removal of stones in maned wolves affected by cystinuria, a relatively common condition in this species. In these cases, medical management must accompany surgical intervention, as they are likely to recur. Urethral obstruction may be a life-threatening condition, and the management of these cases may require perineal urethrostomies when medical management is not sufficient. Marsupialization of the bladder to the ventral body wall has been used to establish patency and drainage in cases of extreme, repeated urinary tract obstruction, but this approach only should be used as a last resort. Risks may be life threatening and include repeated urinary tract infections, dermatitis, and urine scalding at the stoma site, dehiscence and detachment of the bladder from the body wall, and possible peritonitis.

Gastric dilatation with volvulus (GDV) and gastric dilatation (GD) without volvulus have been documented in deep-chested canids such as maned, red, and gray wolves. GDV is an acute, life-threatening condition and often is recognized on postmortem examination following unexpected and sudden death. The antemortem diagnosis of GDV and GD is made on the basis of clinical signs and appearance and confirmed by radiography. The predisposing factors in these species are unknown, but the same risk factors as in domestic dogs have been considered, including the protein source of the diet, the kibble size, the amount of food offered, and the individual's age. Feeding an animal shortly after an anesthetic event has been anecdotally linked to GDV. Prompt recognition is vital to survival, and surgical intervention is the only way to correct GDV.

Ovariohysterectomies and castrations are performed for management and contraceptive reasons and for managing reproductive disorders, including pyometra and reproductive tract neoplasms. A reversible vasectomy technique has been documented in bushdogs, and the technique is applicable to other canid species.[7]

PHYSICAL EXAMINATION AND DIAGNOSTICS

The domestic dog is an appropriate model for the physical examination of all canid species. Baseline clinical parameters are similar to those of the domestic dog, although species-specific ranges are available for many species (Tables 46-3 and 46-4).[18,25,35]

DISEASE

Infectious Disease

Canids are susceptible to all diseases of domestic dogs, and special attention is given in this chapter to those of particular importance. Three viral diseases are of outmost importance because of their impact on wild canid populations: rabies, canine distemper, and canine parvovirus.

Rabies is a zoonotic disease caused by a lyssavirus in the Rhabdovirus family. Domestic and wild canid species are geographic reservoirs that maintain species-associated strains that may affect all mammalian species. The distinction between domestic and wild canid rabies may be blurred in areas where domestic canid strains are present but may be maintained by wild canid populations.[36] For instance, a domestic dog strain of rabies has been transmitted by coyotes in south Texas (United States) and Mexico.[5] Rabies has been a continued epizootic threat to the survival of the Ethiopian wolf[33,40] and the African wild dog,[12] and many other canid populations are at risk, specifically following the introduction or spread of domestic dog strains.[33] Jackals often are affected by canine rabies in Africa,[36] but jackals are capable of maintaining rabies cycles independently of domestic dogs.[48] Fluctuations in populations of fox species and raccoon dogs may be attributed to rabies epizootics, even though these species are reservoir hosts for specific strains throughout their range. Oral vaccination of wildlife using recombinant vaccines has been an effective rabies control strategy in certain parts of the world,

TABLE 46-4

Reference Ranges: Serum Biochemical Parameters of Select Canid Species

Parameter	Gray Wolf (*C. lupus*)[3]	Maned Wolf (*C. brachyurus*)[3]	African Wild Dog (*L. pictus*)[3]	Arctic Fox (*A. lagopus*)[3]	Crab-Eating Fox (*C. thous*)[22]
Total protein (g/dL)	5.5–6.9	5.4–7.0	5.5–6.5	5.7–7.1	4.6–9.4
Albumin (g/dL)	3.0–3.8	2.7–3.5	2.8–3.6	3.0–3.8	2–6.2
Globulin (g/dL)	2.1–3.3	2.4–3.8	2.5–3.3	2.3–3.9	1.9–7.5
Calcium (mg/dL)	9.2–10.8	9.1–10.5	9.3–10.9	8.3–11.1	
Phosphorus (mg/dL)	2.2–5.4	3.3–8.5	2.6–6.4	2.1–5.1	
Sodium (mEq/L)	144–154	141–149	144–152	144–154	
Potassium (mEq/L)	4.1–5.1	4.3–5.3	3.9–4.7	4.1–5.3	
Chloride (mEq/L)	112–120	110–118	112–120	108–118	
Creatinine (mg/dL)	0.7–1.7	0.9–1.7	0.9–1.5	0.7–1.1	0.5–1.5
Urea nitrogen (mg/dL)	14–32	14–32	15–33	7–39	22–87
Cholesterol (mg/dL)	118–248	203–571	199–311	151–223	
Glucose (mg/dL)	91–157	90–140	113–181	109–189	

g/dL, Gram per deciliter; *mEq/L*, milliequivalent per liter; *mg/dL*, milligram per deciliter.

and individuals under human care often are immunized with injectable killed rabies vaccine products.

Canine distemper virus (CDV) poses a worldwide threat to canid populations. Natural epizootics occur in wild populations, but the periodic introduction and maintenance of this virus in domestic dogs poses a threat to endangered species such as African wild dogs and Ethiopian wolves.[44,45] CDV infection has occurred in African wild dogs despite vaccination.[48] Vaccine-induced CDV infection has occurred or been suspected following the use of modified-live vaccines in canid species, including gray foxes (*Urocyon cinereoargenteus*),[14] African wild dogs,[9] and bushdogs.[26]

Canine parvovirus is very common in serosurveys of wild canid populations and is a likely factor in juvenile mortality in some species. Parvovirus has caused significant morbidity and mortality in captive animals, with notable cases in bushdogs.[17] Vaccination using modified live vaccines has raised concerns about causing disease in some species and is not recommended for vaccination of maned wolf pups until protective titers are present after using a killed parvovirus vaccine.[35]

Canine adenovirus causes hepatitis in domestic dogs and may affect all canid species. In some species, the disease has a clinical presentation similar to that of canine distemper and has been dubbed “fox encephalitis” because of the predominance of neurologic signs.

All bacterial diseases of domestic dogs may affect their nondomestic counterparts. Brucellosis and leptospirosis have been of concern in certain coyote populations, and numerous strains of leptospira organisms have been suspected in individual infections. Serosurveys of coyote and swift fox (*Vulpes velox*) populations within the geographic range of *Yersinia pestis* (plague) have suggested that infection is common within the endemic range and may play a role in the epidemiology of their disease by carrying flea vectors.

Neorickettsia helminthoeca is a rickettsial organism that causes salmon poisoning in canids. The organism is transmitted by *Nanophyetus salmincola*, an intestinal fluke of canids in the northwestern United States and southwestern Canada.[18] Canids become infected by ingesting fish or amphibians with encysted metacercariae, although the flukes themselves do not cause clinical disease. *Anaplasma phagocytophilum* has been reported as the cause of acute respiratory disease, lethargy, and neurologic signs in captive maned wolves at one facility in Virginia (eastern United States), although seroprevalence in that population suggests that infection is also possible without overt clinical signs.[30]

All known parasitic diseases of domestic dogs are likely to affect wild canids within a certain geographic range. *Giardia, Cryptosporidium, Eimeria*, and *Isospora* are often seen in nondomestic canids; clinical signs are similar to those seen in domestic dogs and are most significant in juveniles. Babesiosis has been reported in maned wolves in the United States[31] and in South America.[4]

Roundworms, hookworms, and whipworms affect all canids and are suspected to be pathogenic in pups, but clinical disease is often absent in adults. *Dirofilaria immitis* (the cause of heartworm disease) may affect all canid species, although it has been suspected that other parasites may cause cardiac infections. Cardiac ultrasonography detected adult nematodes, suggesting the presence of heartworms in the right pulmonary arteries of two maned wolves that had been prophylactically treated with ivermectin (0.2 mg/kg, orally [PO], monthly) for 2 years prior to detection. Neither wolf showed signs of clinical infection, and blood-based screening tests had been negative for both animals.[10] Trichinosis has been diagnosed in wild Arctic foxes (*Alopex lagopus*), and infection is often attributed to feeding on polar bear carcasses.

Spirocerca lupi is a parasite of canids that may be found in the gastric, esophageal, or aortic wall and usually requires a coprophagous arthropod as an intermediate host, but many species may serve as paratenic hosts. Aortic aneurysms and acute death have been associated with parasitism by *S. lupi* in bushdogs[34] and wild coyotes, and may occur in other canids.

Nematodes from the respiratory tract (*Angiostrongylus vasorum*, *Eucoleus aerophilus*, *Crenosoma vulpis*) commonly affect wild canids.[28,29] The renal parasite *Dioctophyma renale* has been documented in maned wolves, bushdogs, raccoon dogs, coyotes, jackals, red and gray wolves, and foxes.[18] The intermediate host is an aquatic oligochete, although canids get infected when consuming piscean, amphibian, or invertebrate paratenic hosts in the endemic geographic areas. The adult worms usually are found in the right kidney, which often becomes nonfunctional. Diagnosis may be made by ultrasonography or by the presence of ova shed in the urine.

Hepatozoonosis affects coyotes in North America, but recent studies suggest that a great diversity of *Hepatozoon* species occur throughout the range.[41] Encephalitozoonosis is an important disease affecting wild and farmed foxes worldwide and has been reported in African wild dog pups.[45]

Wild canids are reservoirs for two genera of cestodes (*Taenia* and *Echinococcus*), which are significant zoonotic parasites and a risk to other mammalian species.[18] Clinical disease is rare in the canid hosts, but the eggs are shed in canid feces and ingested by an intermediate or aberrant host where clinical signs may occur. Three *Echinoccoccus* species (*E. granulosus*, *E. multilocularis*, and *E. vogeli*) maintain their cycles through a definite canid host and its herbivorous prey (rodents, rabbits, sheep, goats, deer, camels, macropods). *Dipylidium caninum* may affect wild canid species, and transmission usually occurs by ingestion of fleas.[18]

Pancreatic flukes (*Eurytrema procyonis*) have been documented in maned wolves in the Midwestern United States[15] and in foxes throughout the United States. Clinical signs are associated with maldigestion and include weight loss and poorly formed stools.

Many ectoparasites (fleas, ticks, chiggers, and lice) are known to affect canids. They may be a significant cause of anemia in juveniles and neonates and may serve as vectors of tick-borne diseases (anaplasmosis, babesiosis, ehrlichiosis, borreliosis).

Noninfectious Diseases

Inflammatory bowel disease (IBD) is a common cause of chronic GI disease (vomiting and diarrhea), weight loss, poor pelage, and overall malaise in several large canid species (notably maned wolves and gray wolves). Hypoproteinemia, specifically hypoalbuminemia, is a significant component of the disease, often leading to ascites. Profound hypoalbuminemia and ascites are poor prognostic indicators. IBD is an inflammatory cell infiltration of the lamina propria (typically lymphocytes, plasma cells, eosinophils, macrophages, and neutrophils), but the predominance of each cell type may correspond to slightly different disease characterization, prognosis, and treatment needs. The term "IBD" should never be used to characterize clinical signs, as these are shared with other conditions. Differential diagnoses include other malabsorption diseases, pancreatic disease (exocrine insufficiency), parasitic and infectious diseases (viruses and bacterial overgrowth), enterocolitis, dietary intolerance, and neoplastic disease. IBD is not synonymous with dietary intolerance or a food allergy to a dietary component.

The etiology of IBD is typically unknown but is believed to involve impaired immunoregulation in the response of gut-associated lymphoid tissue to antigenic stimuli. Bacteria in the gut lumen and parasitic or dietary agents may serve as antigenic initiators to an excessive, chronic gut immune inflammatory response. A presumptive diagnosis of IBD often is made on the basis of clinical signs after excluding other differential diagnoses, but a confirmatory diagnosis requires gut biopsies. Primary treatment modalities mimic those used in IBD in domestic dogs and require supportive care based on the severity of signs and clinical pathology findings. Immunomodulation (either through corticosteroids, immunosuppressive agents, or sulfasalazine), dietary modification (hypoallergenic diets, easily digestible diets), antibiotics (to decrease bacterial overgrowth), and supportive care (fluids, possibly colloids in cases of hypoproteinemia) are the main components of therapy. Supplementation of cobalamine and folate may be beneficial.

Cystinuria is a prevalent condition in maned wolves, both in human care and in the wild, and may have a genetic basis.[15] Cystinuria is often subclinical,[15] but the precipitation of calculi in the urinary tract may have life-threatening consequences if urinary obstructions occur. Obstructions are more likely to occur in males (because of the size and length of the urethra) than in females, although cystinuria occurs equally in both sexes. The persistence of cystine crystals in the urinary tract may predispose to urinary tract infections. Long-term (likely lifelong) medical therapy is essential to managing cystinuria. Surgery is indicated in cases of urethral obstructions that cannot be relieved or when large calculi (stones) are present. Medical therapy is aimed at affecting the solubility of cystine to prevent crystal precipitation and stone formation and reducing the concentration of cystine in the urine. Urine alkalinization has been a mainstay of medical management, as urine pH affects the solubility of cystine. Potassium citrate is the preferred urine alkalinization agent. Sodium bicarbonate has been used as a urinary alkalinization agent, but it is not preferred, since sodium intake increases cystine excretion. Dietary manipulation, specifically decreasing sodium intake and reducing protein from animal sources (which are higher in sulfur-containing amino acids), is a theoretical means to reducing cystinuria but has not been systemically tested in maned wolves. Tiopronin has been used as a pharmacologic means of modifying the cystine molecule into a more soluble form in domestic dogs[16] and has shown some success in maned wolves despite the high cost, low availability in the United States, and potential side effects with long-term use. Other thiol-based agents such as D-penicillamine have been used with some success in maned wolves with cystinuria. Close monitoring of maned wolves for stranguria is an essential part of the routine care of this species.

Pododermatitis may cause significant morbidity in canids[35] and is an important disease in neonates. Because of their predisposition to dig, many canids suffer traumatic lesions to their pads, including abrasions, pad or nail avulsions, and lacerations. Wounds may become infected, often leading to pododermatitis. Neonates housed on rough surfaces or den boxes may dig or repeatedly push aside bedding material, leading to lesions that often get infected because of the limited mobility of the neonates. *Staphylococcus* spp. and gram-negative bacteria often invade pododermatitic lesions and likely reflect contamination from the adjacent skin or of enteric origin. Interdigital dermatitis and edema have been seen in maned wolves, Mexican gray wolves, fennec foxes (*Vulpes zerda*), and other species. Although the etiology is unknown, tissues between the digits and pads on the plantar surface become erythematous, abraded, and moist. Some of these lesions may be the result of excessive moisture leading to dermatitis and resolve with appropriate disinfection and oral antimicrobials. In some instances, biopsy of nonhealing lesions has been suggestive of an auto-immune component and has responded to treatment with oral prednisone in addition to antibiotics.

A few cases of progressive retinal atrophy have been documented in red and gray wolves.[35] Gingival hyperplasia (proliferative gingivitis) may occur as a result of chronic gingivitis and dental disease and has been documented in maned wolves of all ages. A genetic predisposition is also possible.

Prolonged, cyclic exposure to endogenous steroids associated with the obligate hormonal pseudopregnancy that follows ovulation in female canids has been associated with uterine pathology, including the cystic endometrial hyperplasia–pyometra complex. Progressive uterine growth, infertility, infections, neoplasms, and mammary proliferation have been linked to the use of steroid contraceptives and are not recommended for long-term contraception. Specifically, the use of melengestrol acetate implants for contraception has been associated with endometrial hyperplasia, hydrometra, fibrosis, adenomyosis, and uterine mineralization.[27]

Although all canids are predisposed to the same neoplasms as their domestic canine counterparts, cranial, oral, or facial squamous cell carcinomas seem to be disproportionately common in Mexican gray wolves (*Canis lupus baileyi*). Dysgerminomas have been often reported in maned wolves.[15]

REPRODUCTION

The reproductive system of canids is unique among mammals. Most canids exhibit monogamy, exceptionally long proestrous and diestrous phases, a copulatory lock, behavioral suppression of mating in the subordinate young within a social group, and obligate pseudopregnancy in subordinate females.[2] Most wild canids are seasonal breeders, but notable exceptions exist in the small or tropical canids such as bushdogs, in which the females do not have a rigid, single breeding cycle.[8] Some species may naturally exhibit seasonality in the wild, but not in captivity, and the seasonality of tropical species may be dependent on prey cycles, which follow seasonal rainfall.[2] Mounting evidence suggests that some species, notably the smaller canid species, likely have induced estrus cycles.[3] The copulatory lock is an important mechanism in canid mating behavior, and it may be extremely prolonged in some species such as the fennec fox, with a mean duration of almost 2 hours.[43]

TABLE 46-5

Reproductive Parameters of Select Canid Species

Species	Reproductive Cycle	Gestation (days)	Litter Size
Bat-eared fox (*Otocyon megalotis*)	Monestrus	60–70	2–6
Fennec fox (*Vulpes zerda*)	Monestrus	50–53	1–5
Bushdog (*Speothos venaticus*)	Monestrus or polyestrus	65–70	1–6
Maned wolf (*Canis brachyurus*)	Monestrus	63–67	2–5
Dhole (*C. alpinus*)	Monestrus, possibly seasonally polyestrus	60–62	2–7
African wild dog (*Lycaon pictus*)	Monestrus	69–72	2–20
Red wolf (*C. rufus*)	Monestrus	60–63	4–5
Coyote (*C. latrans*)	Monestrus	60–63	1–18
Mexican gray wolf (*C. lupus baileyi*)	Monestrus	60–63	4–5

Pseudopregnancy is the term used to refer to the prolonged luteal phase following ovulation in canids, which often may be as long as pregnancy. In a pack setting, the hormonal changes associated with pseudopregnancy likely prepare subordinate females to assist in the communal rearing of offspring, and some females may even lactate.[2] Table 46-5 summarizes the reproductive features of select species.

PREVENTIVE MEDICINE

Preventive medicine guidelines for captive canids may follow the same basic principles of domestic dog medicine, and no single protocol is likely to be applicable to all situations. Standardized quarantine guidelines have been established for large canids.[35] Routine prophylaxis against *Dirofilaria immitis* (heartworm) should be considered mandatory in all endemic areas where canids are managed. Routine prevention against ectoparasites is recommended, and most commercially available products used for tick and flea management in domestic dogs may be used in wild species of canids.

Vaccination protocols (Table 46-6) must be designed on the basis of diseases present in the geographic location and the risk of exposure. Rabies, canine distemper, and parvovirus are the “core” diseases affecting canids and deserve special consideration when developing vaccination protocols. Multivalent vaccines have been used in many canid species without adverse effects and are widely available commercially, but some veterinarians prefer to use monovalent products to minimize the risk of possible effects. Modified-live vaccines must be used with caution, as vaccine-induced diseases (distemper and parvovirus) have been seen in some species.[9,14,26] Genetically modified canary-pox vectored vaccines are a safe alternative and are commonly used since they cannot induce disease.

TABLE 46-6

Suggested Vaccine Protocols for Nondomestic Canids

Disease	Vaccine Type	Frequency	Notes
Canine distemper virus (CDV)	All canids: Recombinant canary pox vectored vaccine[a] Modified live vaccines recommended for Mexican gray wolves (*Canis lupus baileyi*)[b] and red wolves (*C. rufus*)[c]	Begin at 6–9 weeks, booster every 2–3 weeks until 16–20 weeks, then yearly or check titers (Rodden AZA)	Recombinant canary pox vectored vaccine[a] is safe, cannot induce CDV disease, and is recommended for all susceptible exotic carnivores[a]
Rabies	All canids: Killed virus vaccine[d,e]	Administer at 16 weeks, booster at 1 year of age, then annually[d] or every third year,[e] depending on product used	A recombinant canary-pox vectored vaccine[f] is available and may be used at veterinarian’s discretion, especially for small canids, then booster yearly
Parvovirus	Killed vaccine safest Modified live vaccine used in red wolves,[g] gray wolves,[c] and adult maned wolves Maned wolves should be vaccinated with a killed vaccine product[h] until protective titers (>80) are present, then boostered with a modified live vaccine to avoid vaccine-associated disease	Begin at 6–9 weeks, booster every 2–3 weeks until 16–20 weeks, then yearly or check titers	Concerns with vaccine-induced disease in canids when using modified-live products, and strategy used for maned wolves may be appropriate for other species

Products available in the United States:
[a]Merial, PUREVAX: ferret distemper vaccine.
[b]Schering-Plough Galaxy D: modified live distemper vaccine.
[c]Pfizer Animal Health Vanguard 5: modified live modified live distemper, canine adenovirus type 1 and 2, parainfluenza and parvovirus vaccine.
[d]Merial IMRAB 1: rabies vaccine
[e]Merial IMRAB 3: rabies vaccine
[f]Merial PUREVAX: feline rabies vaccine
[g]Merial RECOMBITEK: modified live canine parvovirus vaccine.
[h]Fort Dodge FeloVax PCT: killed feline panleukopenia vaccine, includes feline rhinotracheitis and feline calicivirus.

Vaccination against coronavirus, Lyme disease, and leptospirosis should be considered if warranted by local disease risks. It must be noted that despite their taxonomic proximity to domestic dogs, all vaccines used in nondomestic canids are considered "off label."

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