CHAPTER 48

Mustelidae

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NATURAL HISTORY, ANATOMY, AND PHYSIOLOGY

Recent studies have revealed that the Musteloidea emerged approximately 32.4 to 30.9 million years ago in Asia. During the Oligocene, musteloids diversified into four primary divisions: Mephitidae, Ailuridae, Procyonidae, and Mustelidae. Mustelidae arose approximately 16.1 million years ago. The early offshoots largely evolved into the ecologic niches of badgers and martens, whereas later divergences have adapted to other niches, including those of weasels, polecats, minks, and otters.[35]

Extant mustelids are classified in the order Carnivora, suborder Caniformia, family Mustelidae, and subfamily Mustelinae and

Mephitinae. The family Mustelidae currently includes 25 recent genera and approximately 67 species of terrestrial carnivores or piscivores inhabiting all continents except Australia and Antarctica and are also absent in New Guinea, Madagascar and Antarctica. They have been introduced into New Zealand. In the course of evolution, several behavioral adaptations and many physical features have developed, as some species live mainly in the ground (stoat, weasel, polecat) or even partially underground (badger), whereas others are active also above the ground in trees (pine marten). Some have selected marine or fresh water as their preferred habitats most or part of the time (mink, river otter, sea otter).

Included in this family are the smallest living carnivore, the common or least weasel, and the largest representatives, the giant and sea otters in water and the wolverine on land. Mustelid body weights range from under 70 grams (g) (least weasel at 19 centimeters [cm] long) to 45 kg (sea otter at 190 cm long).

The family Mustelidae includes five subfamilies. The weasel-like carnivores (*Mustelinae*) represent the group with the greatest number of species, comprising 10 genera with approximately 33 species including weasels (11 species), polecats (3 species), minks (2 species), grison (1 species), and wolverine (1 species). The subfamily Mellivorinae is represented by only a single species, the honey badger or ratel (*Mellivora capensis*). Subfamily Melinae includes five genera in eight species of badgers represented in Africa, Asia, South America, or wide ranges of northern Eurasia and North America. Skunks (subfamily Mephitinae, recently elevated to Family Mephitidae) are exclusively common in North America. Otters (subfamily Lutrinae) are small to large forms that show the most highly developed adaptations to marine life of all mustelids. They lead an amphibious life and feed mainly on fish or crustaceans. Most mammologists recognize four genera and 13 species.[30]

Most mustelids have a highly flexible spinal column; the limbs are comparatively short, ending in feet with five digits, and they walk either digitigrade or plantigrade. The claws are not (or only partly) retractable. Mustelids lack the clavicle and cecum. They present the typical carnivore dentition with number of teeth varying from 28 to 40. Developed canine (C) teeth are always present and the last premolar (P) in the upper jaw and the first molar (M) in the lower jaw jointly form the “crushing shears” for processing food. The dental formula of weasels is incisors (I) 3/3, C 1/1, P 3/3, M 1/2 on the upper and lower jaws. In the wolverine the formula is I 3/3, C 1/1, P 4/4, M 1/2 upper and lower. Eurasian badger formula is I 3/3, C 1/1, P 4/4, M 1/2 upper and lower, and in the members of the *Lutra* and *Lontra* genera the formula is I 3/3, C 1/1, P 3-4/3, M 1/2 upper and lower. The pine marten has a dental formula of I 3/3, C 2/1, P 4/4, M 1/2 upper and lower (40 teeth total), which is different from that of other mustelids. Glands may be located in various regions of the body surface. The paired anal glands produce odorous secretions characteristic of the species and used for marking their habitat, sometimes for generations. Some species may spray these secretions over long distances as a method to discourage or harm enemies.

In otters, the mandibular salivary glands and lymph nodes lie in the angle of the mandible, whereas the retropharyngeal nodes lie dorsolateral and slightly caudal to the larynx. The thyroid glands of otters are also different from those of other mustelids in that they are long, flat, and tapering, with no isthmus, and closely attached to the trachea. The heart of otters is usually globular with a thick-walled left ventricle and a thin-walled right ventricle. The shape of the heart and thickness of the ventricles should not be confused with ventricular hypertrophy. Otters have a seven-lobed liver. A common hepatic and cystic bile duct joins the duodenum adjacent to the pancreatic duct. The kidneys of otters, like those of cows and cetaceans, are multilobulated. The lungs of otters and badgers are composed of two lobes on the left, three lobes on the right, and an intermediate lobe where the right bronchus terminates.[5,15]

Mustelids are predominantly solitary, sexually dimorphic mammals (males are 25% larger than females). Smaller mustelid species have high metabolic rates. Males and females come together only during the reproductive period, and social communities generally include the mother and offspring. Table 48-1 summarizes the biologic data of selected mustelids.

Members of the family range from the International Union for the Conservation of Nature (IUCN) status Endangered (black-footed ferret) to Near Threatened (wolverine) to IUCN status Least Concern (badger).

Unique Aquatic Adaptations

The family Mustelidae contains numerous fully terrestrial species, two that are semi-aquatic (minks), and a number that are amphibious to fully aquatic (the *Lutrinae*). The latter have adaptations for the aquatic habits that may be relevant for the clinical management. Underwater vision presents challenges for the mammalian eye: the need for increased sensitivity to light, accommodation of the spectral shift toward the blue-green wavelengths, and modification of the ocular focusing capacity because of refractive differences compared with those in air. Different adaptations for these challenges have been proposed, although visual acuity in water is somewhat reduced in some otter species (i.e., Asian small-clawed otter). Little is known of the importance, sensitivity, and mechanisms of hearing in otters, in the aquatic or the terrestrial environment. Olfaction has been retained as an important sense for aquatic mustelids, largely but not exclusively in support of their activities on land. However, evidence suggests that otters have less complex scent production capacities compared with terrestrial mustelids and that scent production capacity in sea otters may be more poorly developed and less important than in other otter species. These changes probably have resulted from the increased importance of vision and the reduced importance of olfaction in the aquatic environment. The long, lean body of Mustelinae species makes them vulnerable to rapid heat loss on land and in the water. Insulation in aquatic mustelids is achieved by means of a dense underfur that prevents water penetration to the skin while providing buoyancy. Because fur is an efficient insulator, furred aquatic mammals require some means of thermoregulation; in sea otters, thermoregulation is conducted through the enlarged rear flippers. In otters and minks, swimming is the primary means of locomotion. These species demonstrate many adaptations that enhance swimming performance and reduce energy expenditure while in the water: body streamlining, large, specialized plantar surfaces for propulsion, and the ability to remain submerged for extended periods. However, most otters, unlike most aquatic mammals, are capable of quadrupedal locomotion on land, and this is why they are considered morphologically intermediate between terrestrial and aquatic mammals.[12]

OUTDOOR AND INDOOR ENVIRONMENTS

Most species tolerate a wide range of temperature ranges. Temperate and cold-adapted species held outdoors need protection from sunlight when the temperature exceeds 50°F (10°C). Tropical species require heated shelters when ambient temperatures drop below 69°F (20°C). Animals kept indoors should not be exposed to temperatures exceeding 78°F (25°C). It is important to be aware that required temperature ranges vary among individuals as well as between species, so individual animals should be given the opportunity to select a comfortable ambient temperature from a gradient provided in the enclosure. Humidity for indoor enclosures should range from 30% to 70% but may be higher for tropical species. The amount of time individuals held indoors are exposed to light should replicate the natural photoperiod of their native environment, particularly for those species that are expected to reproduce in captivity. Currently, data on the effects of varying light intensity or type of light (fluorescent versus natural) on reproductive behavior are not available; however, a correlation exists between the onset of estrus in northern mustelid species.[4] Indoor exhibits should have a negative air pressure of five to eight air changes per hour (for odor control) of non-recirculated air; however, this is not necessarily a requirement and recirculated air may be used in some cases.

TABLE 48-1

Biologic Information of Selected Species of Mustelids

Scientific Name	Common Name	Weight	Geographic Distribution	Distinguishing Features	Life Span	Food
Mustela nivalis	Common weasel Least weasel	Female (F): 30–120 grams (g) Male (M):36–250 g	North Africa, Western Europe, Eastern Siberia; Japan, Alaska, and Northeastern USA, (New Zealand)	Smallest species of family Body size and fur color highly varying	About 1 year	Burrowing voles, true mice, birds, frogs, lizards
Mustela erminea	Ermine, Stoat, Short tail weasel	F: 85–200 g M: 200–310 g	Europe-Eastern Siberia, Japan, Alaska, Northern Greenland, Northern USA, (New Zealand)	Summer fur cinnamon-brown or even yellow on back; underside white	About 1 year	Burrowing voles, true mice, hares, birds, eggs, lizards, frogs
Mustela putorius	European polecat	F: 650–820 g M: 1000–1500 g	Europe	Ancestor of domestic ferret, *M. putorius furo*, facial mask	5–6 years, 10 years and more in isolated cases	Small rodents, rabbits, hares, birds, eggs, frogs, snakes, insects
Mustela nigripes	Black footed ferret	F: 750–850 g M: 900–1000 g	Alberta to northern Texas	Facial mask; black limbs	12 years	Prairie dogs and other small rodents, birds
Mustela lutreola	European mink	400–1200 g	Western Siberia, Eastern Europe, (Western Europe)	Polecat-like; long vibrissae on snout	7–10 years	Mouselike rodents, fishes, crayfish, mollusks, birds, amphibians, reptiles
Mustela vison	American mink	500–2300 g	Canada, USA, (Iceland, north and central Europe, Siberia)	Sparse white spots on chin and ventrum, otherwise very similar to European mink	8–10 years	Same as European mink
Vormela peregusna	Marbled polecat	370–715 g	Southeastern Europe to western China	Spotted back, large ears	8 years	Gerbils, jumping mice, susliks, hamsters, and other rodents
Poecilogale albinucha	White-naped weasel	F: 230–290 g M: 280–380 g	South Africa to Zaire, Uganda	White neck; stripes on back	5 years	Small rodents, birds, snakes, grasshoppers and other insects
Ictonyx striatus	Zorrila or African striped polecat	420–1400 g	Senegal, Ethiopia, and South Africa	Stripes on back; squirts secretion from anal glands for defense	13 years	Small rodents, birds, eggs, insects
Martes martes	Pine marten	F: 800–1300 g M: 1200–1600 g	Western Europe to Western Siberia	Summer fur thin and short, winter fur thick and long	15 years	Mouselike rodents, squirrels, hares, rabbits, birds, eggs, reptiles, amphibians, insects, fruits, berries, nuts
Martes foina	Stone marten or beech marten	F: 1100–1500 g M: 1700–2400 g	Western Europe to Himalayas, and Altai	Similar to pine marten, but heavier, shorter limbs, white throat spot	Unknown	Similar to pine marten
Martes americana	American marten	F: 600–775 g M: 700–1300 g	Canada, north USA	Similar to pine marten; irregular cream to orange spots on throat and chest	17 years	Similar to pine marten
Eira barbara	Tayra	4–6 kilograms (kg)	Northeastern Mexico to Argentina	Dark brown to black body	18 years	Guinea pigs, harelike rodents, birds, reptiles, insects, honey, fruits

Mellivora capensis	Ratel	7–13 kg	Northern India to Arabia, Africa, and south of Sahara	Some animals completely black; forelimbs muscular, with strong claws	Unknown	Small rodents, birds, eggs, lizards, snakes, turtles, frogs, insects, honey, berries, fruits, roots
Meles meles	Badger	7–13 kg in summer; 15–25 kg in fall	Europe, Japan, and southern China	Silvery gray back and flanks; throat, chest, belly and legs black or brown	16 years	Mouselike rodents, small birds, eggs, frogs, lizards, insects, snails, earthworms, fruits, nuts, berries
Taxidea taxus	American badger	6–8 kg in summer; 8–12 kg in fall	Southwestern Canada to central Mexico	Thick dense fur; predominantly gray black with white stripe from nose to root of tail; dark, oblong cheek spot	16 years	Small mammals, birds, eggs, reptiles, insects, invertebrates
Mephitis mephitis	Stripped skunk	1.2–2.5 kg; in the fall up to 5.3 kg	Southern Canada to northern Mexico	Black, with mostly two white lateral stripes; spray secretion from anal glands up to 6 m with accurate aim into eyes of attacker	10 years	Small rodents, birds, eggs, insects, worms, fruits, berries, corn
Lutra lutra	Eurasian otter	5–12 kg	Eurasia, North Africa, Sri Lanka, Taiwan, Sumatra, Java	Shiny dark brown or chestnut brown back; fingers and toes joined by swimming membranes	22 years	Fishes, crustaceans, clams, frogs, small rodents, worms
Lontra canadensis	Nearctic river otter	3.4–15.4 kg	Canada, USA	Head blunt, small, flat bullous nose; small eyes; interdigital webs	14 years in wild; 16–18 years in captivity	Fish (primarily), crustaceans (cray fish); amphibians; insects, birds, mammals
Pteronura brasiliensis	Giant otter	22–32 kg	Venezuela to Argentina	Very dark fur; chin, throat, and chest have cream-colored spots; flattened tail; swimming membranes	13 years	Fishes, crustaceans, other aquatic animals
Enhydra lutris	Sea otter	F: 36 kg M: 46 kg	Bering Sea to California	Largest mustelid by weight; light brown to nearly black pelage; interdigital webs	In wild 22 years (females) 15 years (males)	Generalist predator; decapod crustaceans, gastropod and bivalve mollusks, echinoderms
Gulo gulo	Wolverine	10–20 kg	Scandinavia, Siberia, Alaska, Canada, Western USA	Bushy tail; long flowing fur; thick, strong paws; partly retractable claws	18 years	Rodents, harelike rodents, reindeer, elk, carcasses, ground-nesting birds, berries

Items in parenthesis refer to areas where a particular species as been introduced.

Fresh drinking water should be provided at all times. Nonfiltered water, contained in pools or moats and used for swimming, should be changed on a regular basis. Even if water is filtered, it should be completely changed periodically. Mustelids should not be given access to pools that have recently been treated with chlorine (levels should be <0.5 parts per million [ppm]). For otters that normally inhabit fresh or brackish water environments, dissolved nutrients should be monitored and water changes performed, as appropriate. It is suggested that the coliform level not exceed 400 colony forming units per milliliter (CFU/mL) (water with a level of 100 CFU/mL is reported to be safe for humans). Filtration should be used in closed pools for otter. Sand filters, pool pumps, charcoal filters, and ozone pressure sand filters have all been used effectively. Drain outlets and filter and skimmer inlets should be covered to prevent furnishings from obstructing them or from otters getting stuck in them. Natural flow-through systems work well in otter exhibits. Water flowing in must be clean and pollutant free. All uneaten food items should be removed from pools on a daily basis. Because minks are highly susceptible to methyl mercury toxicity, pools need to be maintained at a neutral or basic pH (acidic pH enhances methylation of mercury).

Controlling of sounds and vibrations that may be detected by mustelids is important to their well-being. Anecdotal reports of loud noises and vibrations of certain amplitude affecting parturition and early kit rearing in mustelids have been published.[3,4]

Habitat Design and Containment

Exhibits should be designed to satisfy the physical, social, behavioral, and psychological needs of the species while closely replicating their habitat in the wild. Enclosure size for arboreal and terrestrial mustelids is based on species' and individual needs (e.g., juveniles versus adults versus geriatric animals). Exhibits that are provided extensive enrichment and are structurally varied may be smaller than exhibits lacking these characteristics. (Note that enrichment items must be chosen carefully, since many mustelid species are prone to chewing and ingesting enrichment parts, putting them at risk of gastrointestinal [GI] foreign body obstruction). Recommended exhibit sizes are based on species size, behavioral repertoire, home range size, daily movements, and activity patterns. Detailed information is given in the Mustelid (Mustelidae) and Otter (Lutrinae) Care Manuals provided by the Association of Zoos and Aquariums, Small Carnivore Taxon Advisory Group.

Animal and human safety must be kept in mind when designing and building mustelid exhibits. Additionally, mustelids are not well suited for free-ranging exhibits because of their uncanny ability to escape. Exhibits must be designed to prevent them from digging, jumping, climbing, or swimming out of enclosures. Outdoor exhibits should have containment perimeters, tops and hotwire 3 to 5 feet (ft.; 1–1.52 meters [m]) installed above ground level to prevent them from climbing and falling. For burrowing species (e.g., badgers), the bottom of the containment fence may need to be buried to a sufficient depth and angled toward the center of the exhibit to prevent escape. For amphibious species (e.g., otters), optimal land-to-water ratios are species dependent. These ratios may need to be changed as exhibit size increases or decreases (e.g., smaller exhibits will require a higher land area proportion within the ratio).[3,4]

FEEDING AND NUTRITION

Within the *Mustelidae* family, food habits vary significantly. Some are strict carnivores (ferrets, weasels, polecats, etc.), some are omnivorous (skunks, badgers or tayras), and some are piscivorous (fish and crustacean eaters such as otters) (see Table 48-1). Mustelids have a relatively simple stomach and a short GI tract and, as mentioned above, no cecum. The more omnivorous species have flattened molars. Captive mustelid species are fed on a great variety of items: commercial dry dog food, mink food, and cat food, and cereal diets mixed with meat, fresh or frozen fish, shellfish, crabs, and crayfish. Fruits, vegetables (carrots, lettuce, green beans, cucumber, collard greens, kale, potatoes, among others), eggs, and live or killed food items (crickets, mealworms, mice, prairie dogs) have also been incorporated into captive diets. Target dietary nutrient values for mustelids are based on several sources. The cat is typically the model species used to establish nutrient guidelines for strict carnivorous animals. The National Research Council (NRC, 2006, for dogs and cats), and Association of American Feed Control Officials (1994, for cats) have provided recommendations. A limited amount of information has been provided by the NRC publication on mink and foxes, which represents the requirements of another mustelid species (Table 48-2). The complete dietary requirements of domestic ferrets are still unknown, so no one particular diet is currently being recommended over another. In the ferret and mink diet, the protein should be of high quality and easily digestible because of their short GI transit time of 3 to 4 hours. Generally, most mustelids need a diet high in good-quality meat protein and fat and low in complex carbohydrates, inclusive of sugars, and fiber. High levels of protein from plant sources have been associated with urolithiasis in mustelids and are therefore undesirable. Food should be offered at least twice a day, and water must be available at all times. When developing appropriate dietary management plans for a specific mustelid species, the following should be considered: feeding ecology, target nutrient values, food items available at zoos, and information collected from diets offered by institutions successfully maintaining and breeding for the species.

RESTRAINT AND HANDLING

Even though some captive mustelids may be gentle with their keepers, all members of this family may be handled with nets, snares, or squeeze cages. Caution must be used while managing wild mustelids, as they have needle-sharp teeth and are agile and aggressive and may inflict severe bites. They are also potential vectors of rabies, so they should be handled with caution. Leather gloves should be used by operators when handling any kind of mustelid, whatever the size. The ferret is best restrained when grasped above the shoulders, with one hand gently squeezing the forelimbs together and the thumb under the animal's chin. Minks are grasped by the tail with one hand, while the other hand grasps the animal behind the neck, with the thumb and finger around the head. Polecats, ermines, weasels, and martens are better restrained initially with a net when an injection has to be administered by hand. Skunks defend themselves by spraying the secretions of the anal sacs, and they may bite as well. The defensive position assumed by a threatened skunk is hindquarters facing the enemy, feet planted firmly on the ground, and tail straight up in the air. They should be captured with a net from behind a shield of glass or plastic, or the handler should wear goggles and protective rain gear. Larger mustelids such as otters, badgers, and wolverine may be placed in a small squeeze cage for manual injection of a tranquilizer or directly injected by means of a pole syringe or a blowpipe.[16]

Mustelids are susceptible to stress caused by improper handling and transport. Fresh water and marine otters are particularly susceptible to stress-associated exertional myopathy. Different techniques have been developed for safe management of this species. Only trained personal should handle mustelids, and usually, a combination of physical restraint and chemical restraint is advocated to reduce stress and avoid capture myopathy. The duration of restraint should be brief, and care should be taken to avoid trauma to the oral cavity and limbs. As mentioned above, sea otters are extremely susceptible to stress caused by improper handling and transporting. Different techniques have been developed for the safe management of this species.[19,24]

Chemical Restraint

Different drugs have been used extensively for the chemical immobilization of mustelids. In most species, dissociative-benzodiazepine–α_2-agonists combinations have been used and are highly recommended for induction or short-term anesthesia. Ketamine in

TABLE 48-2

Nutrient Requirements and Target Nutrient Ranges for Selected Carnivore Species

Nutrient	Cat* (National Research Council [NRC], 1986)	Dog* (NRC, 1974)	Mink† *Mustela vison*	Artic Fox‡ *Vulpes vulpes* (NRC, 1982)	Asian Small-Clawed Otter§ *Aonyx cinerea*
Protein %	24	22	38 (23.9)	24.7	24–32.5
Fat %	—	5	—	—	15–30
Vitamin A, international unit per gram (IU/g)	3.3	5.0	5.93	2.44	3.3–10
Vitamin D (IU/g)	0.5	0.5	—	—	0.5–1.0
Vitamin E, milligram per kilogram (mg/kg)	30	50	27	—	30–120
Thiamin (mg/kg)	5.0	1.0	1.3	1.0	1–5
Riboflavin (mg/kg)	4.0	2.2	1.6	3.7	3.7–4.0
Pantothenic acid (mg/kg)	5.0	10.0	8.0	7.4	5–7.4
Niacin (mg/kg)	40.0	11.4	20.0	9.6	9.6–40
Pyridoxine (mg/kg)	4.0	1.0	1.6	1.8	1.8–4
Folacin (mg/kg)	0.80	0.18	0.5	0.2	0.2–1.3
Biotin (mg/kg)	0.07	0.1	0.12	—	0.07–0.08
Vitamin B_{12} (mg/kg)	—	0.022	—	—	0.02–0.025
Calcium %	0.8	1.1	0.40 (0.3)	0.6	0.6–0.8
Phosphorous %	0.6	0.9	0.40 (0.3)	0.6	0.6
Potassium %	0.4	0.6	—	—	0.2–0.4
Sodium %	0.05	—	—	—	0.04–0.6
Magnesium %	0.04	0.04	—	—	0.04–0.07
Iron (mg/kg)	80	60	—	—	80–114
Zinc (mg/kg)	50	50	—	—	50–94
Copper (mg/kg)	5.0	7.3	—	—	5.0–6.25
Iodine (mg/kg)	0.35	1.54	—	—	1.4–4.0
Selenium (mg/kg)	0.1	0.11	—	—	—

*National Research Council: *Nutrient requirements of dogs and cats*. Washington, DC, 2006, National Academy Press.
†Growing and weaning to 13 weeks. Numbers between parentheses are for maintenance (from National Research Council: *Nutrient requirements for minks and foxes*. Washington, DC, 1982, National Academy Press).
‡National Research Council: *Nutrient requirements for minks and foxes*. Washington, DC, 1982, National Academy Press).
§Maslanka CS: Asian small-clawed otters: Nutrition and dietary husbandry. In: *Nutrition Advisory Group handbook*, 1999.

combination with midazolam, diazepam, xylazine, medetomidine, or acepromazine (*caution:* hyperthermia or hypothermia) to improve muscle relaxation. Xylazine, medetomidine, or dexmedetomidine combined with ketamine has been recommended to improve muscle relaxation, and both combinations may be reversed with atipamezole (2.5 milligram [mg] per 5 mg medetomidine, and 1 mg per 8–12 mg xylazine).[2,13,27] Tiletamine–zolazepam is another option. Doses ranging from 2.2 to 22 mg/kg have been reported for numerous species of mustelids; higher doses result in prolonged recovery. In otters, the usage of a low dose of tiletamine–zolazepam to achieve anesthetic induction, and supplementation with isoflurane or ketamine (5 mg/kg) for maintenance, has been advocated. Flumazemil (0.05–0.1 mg/kg) may be used to antagonize the zolazepam portion of this combination to hasten recovery, but its usage has not been reported in mustelids other than the Nearctic river otter.[38] Drugs and dosages commonly used to provide chemical restraint and sedation in selected mustelids are listed in Table 48-3. These combinations usually provide short periods of chemical restraint (30–45 minutes). If longer periods of anesthesia are needed, inhalation anesthetics (isoflurane and sevoflurane) delivered via an induction chamber, mask, or endotracheal tube is efficient, although the results of chamber induction with inhalation agents may vary and cause excitement in some species. Otters hypoventilate during inhalation anesthesia and require assisted ventilation to prevent hypoxemia and hypercarbia.[26]

Whenever possible, the following parameters should be recorded when immobilizing or anesthetizing a mustelid: actual weight, relative oxyhemoglobin saturation (clamp located on tongue, lips, ears, toes), heart and respiratory rates, and rectal temperature. Possible anesthetic complications include respiratory depression (apnea, bradypnea, tachypnea, hypoxemia), hyperthermia, hypothermia, bradycardia, tachycardia, poor myorelaxation, and excitability during recovery. Hypoventilation has been reported to be a cause of mortality in otters with the use of inhalation anesthesia. During recovery from anesthesia, animals should be kept in a quiet, dark denning box or cage or in a confined area to facilitate smooth recovery from anesthesia.[26]

DIAGNOSTICS

Blood may be collected from various sites; the technique and site chosen depend on the species, how much blood is needed, and operator preference. Sites include the jugular vein, cranial vena cava, ventral coccygeal artery, median caudal vein, lateral saphenous vein,

TABLE 48-3

Drugs and Dosages Recommended for Immobilization of Selected Mustelids

Species	Recommended Anesthetic Combination (milligram per kilogram [mg/kg])	Comments/Alternative
American badger	Tiletamine-zolazepam (4.4)	Ketamine (15), xylazine (1)
American river otter	Ketamine (8–12) + midazolam (0.25–5) / Ketamine (3) + medetomidine (0.030) (atipamezole)	Ketamine (10–12) + diazepam (0.3–5) / Tiletamine–zolazepam (4) + flumazenil (0.08)Respiratory depression may occur
Asian small-clawed otter	Ketamine (15–18) + midazolam (0.75–1)	Ketamine (4–5) + medetomidine (0.1–0.12) (atipamezole) Respiratory depression may occur
Black footed ferret	Ketamine (3) + medetomidine (0.075) (atipamezole)	Ketamine (15) + diazepam (0.1)
Ermine and weasel	Ketamine (5) + medetomidine (0.1) (atipamezole)	Ketamine (3)/ Tiletamine-zolazepam (11–22)
Eurasian badger	Ketamine (5–10) + medetomidine (0.05–0.1) (atipamezole)/ tiletamine–zolazepam (10)	Ketamine (10–16) + xylazine (2–6)/ medetomidine (0.04) + tiletamine–zolazepam (2.5)
Eurasian otter	Ketamine (5) + medetomidine (0.5) (atipamezole)	Ketamine (15) + diazepam (0.5) Respiratory depression may occur
Ferret	Ketamine (10–30) + xylazine (1–2) or diazepam (1–2) or acepromazine (0.05–0.3)	Tiletamine-zolazepam (22) Recovery time may be prolonged
Giant otter	Ketamine (8.5–10.6) + xylazine (1.5–2)	Prolonged recovery
Marten	Ketamine (10) + medetomidine (0.2) (atipamezole)	Ketamine (60) + xylazine (12)
Mink	Tiletamine–zolazepam (15) / Ketamine (40) + xylazine (1)	Ketamine (5) + medetomidine (0.1) (atipamezole)
Ratel (honey badger)	Tiletamine–zolazepam (2.2)	Ketamine (6) + xylazine (0.5)
Sea otter	Butorphanol (0.5)/ oxymorphon (0.3)	Fentanyl (0.3) + azaperone (0.25) *Caution:* Numerous reports of fatal complications
Stripped skunk	Tiletamine–zolazepam (10)	Ketamine (15) + acepromazine (0.2)
Tayra	Tiletamine–zolazepam (3.3)	
Wolverine	Ketamine (5–8) + medetomidine (0.1–0.15)	Ketamine (20) + acepromazine (0.2)

cephalic vein, and femoral vein. Published reference ranges for hematologic and serum biochemistry analyses for selected mustelids are listed in Tables 48-4 and 48-5. Techniques for urine collection, urinary catheterization, splenic and bone marrow aspiration, placement of intravenous and intraosseous catheters, administration of fluids, and blood transfusion have been described for ferret and may be useful when treating other mustelids.[33] A technique of mandibular salivary gland biopsy for rabies testing has been developed in Nearctic river otters.[39] Other diagnostic techniques such as ultrasonography, electrocardiography, radiography, and auscultation are applicable but vary for each species.

DISEASES

Viral and Bacterial Diseases

The following viral diseases have been reported in mustelids: Aleutian mink disease (plasmacytosis), influenza, canine distemper, rabies, rotavirus diarrhea, infectious canine hepatitis, pseudorabies (Aujeszky disease), transmissible mink encephalopathy, mink enteritis, epizootic catarrhal enteritis of ferret (coronavirus) feline panleukopenia, canine parvovirus, feline leukemia, Powassan virus disease (arbovirus), herpes, and necrotizing encephalitis (herpes simplex).[18,21–23]

The following bacteria have been identified as pathogenic in mustelids: *Helicobacter mustelae*, *Desulfovibrio* spp., *Campylobacter jejuni*, *C. coli*, *Salmonella* spp., *Clostridium perfringens* type A, *C. botulinum*, *C. welchii*, *Mycobacterium* spp., *Actinomyces* spp., *Pseudomonas aeruginosa*, *P. putrefaciens* (also known as *Shewanella putrefaciens*), *Streptococcus* spp., *Staphylococcus* spp., *Erysipelothrix rhusiopathiae*, *Escherichia coli*, *Klebsiella pneumoniae*, *K. oozaenae*, *Bordetella bronchiseptica*, *Listeria monocytogenes*, *Yersinia pestis*, *Y. ruckeri*, *Bacillus anthracis*, *Brucella abortus*, *Pasteurella multocida*, *P. pseudotuberculosis*, *Francisella tularensis*, *Leptospira* spp., *Bacteroides melanigenicus*, *Proteus vulgaris*, *P. mirabilis*, and *Plesiomonas shigelloides*.

Fungal diseases are rarely reported in mustelids, but those cited include histoplasmosis, cryptococcosis, blastomycosis, coccidiomycosis, mucormycosis (*Absidia corymbifera*), adiaspiromycosis (*Emmonsia crescens*), and dermatomycosis (*Microsporum* sp. and *Trichophyton* sp.).

Table 48-6 contains information about some common infectious diseases reported in mustelids.

Parasitic Diseases

Although not generally associated with disease, numerous external and internal parasites have been identified in both wild and captive mustelids. Table 48-7 includes data on selected parasites reported to cause disease in mustelids. Parasitic diseases are also important for wild animals undergoing translocation because of the immune suppression possibly induced by stress.[22,25]

Ectoparasites

External parasites reported to affect mustelids include the following: fleas (*Ctenocephalides canis*, *C. felis*, *Pulex irritans*, *Nosopsyllus fasciatus*, *Ceratophyllus gallinae*, *Chaetopsylla globiceps*, *Parceras melis*, *Spilopsyllus cuniculi*, *Monopsyllus sciurorum*), ticks (*Ixodes ricinus*, *I. bansksi*, *Amblyomma americanum*, *Dermacentor variabilis*), lice (orders Mallophaga, and Anoplura), demodectic mange (*Demodex* sp.), sarcoptic mange (*Sarcoptes scabiei*), ear mites (*Otodectes cynotis*), myiasis (*Cuterebra* spp., and *Wohlfahrtia vigil*), Guinea worm (*Dracunculus insignis*), filarial dermatitis (*Filaria taxidae*). Mite, tick, and flea treatments include concurrent treatments of the environment and the animals. Topical treatment should include those approved for use in

TABLE 48-4

Reference Range for Hematologic Parameters of Selected Mustelid Species[a]

North American Parameter*	Nearctic river otter	Eurasian otter	Mink†	Striped skunk	Ferret	European polecat‡	Striped skunk‡
Erythrocytes $\times 10^6$/microliter (μL)	6.10–14.50	5.2–7.8	8.07 ± 0.67	6.8–12.2	6.35–11.2	8.39 ± 1.86	8.08 ± 0.68
PCV (%)	32.2–60.8	37.8–69.1	45.9 ± 3.1	42–61	36.7–54.9	43.6 ± 8.7	43.0 ± 6.5
Hemoglobin, gram per deciliter (g/dL)	10.4–19.0	11.0–19.9	15. 6 ± 1.1	15–18	11.1–17.1	14.3 ± 2.7	13.4 ± 1.1
MCV, (fL)	38.3–49.0	60.7–105.2	56.9 ± 1.9	—	45.6–54.7	52.1 ± 407	53.0 ± 2.6
MCH, picogram (pg)	11.3–15.8	16.3–26.9	—	—	14.0–17.6	17.3 ± 1.2	17.0 ± 0.4
MCHC (%)	27.8–39.2	24.6–30.9	34.0 ± 0.52	—	30.7–32.9	33.2 ± 1.9	31.8 ± 1.2
WBC (10^3/μL)	4.7–33.2	3.1–19.2	6.49 ± 2.02	4-0–19	2.0–9.8	6.20 ± 2.36	8.01 ± 3.12
Neutrophils (10^3/μL)	3.0–28.2	1.41–12.86	2.64 ± 1.27		0.62–3.33	2.88 ± 1.63	4.22 ± 2.43
Band neutrophils (10^3/μL)	0–0.48	0–1.8	0.008 ± 0.020	—	—	0.09 ± 0.05	0.22 ± 0.38
Lymphocytes (10^3/μL)	0.12–4.95	0.58–3.84	3.12± 1.05	—	—	2.98 ± 1.73	3.08 ± 1.65
Eosinophils (10^3/μL)	0–1.83	0–1.39	0.47 ± 0.44	—	—	0.24 ± 0.19	0.18 ± 0.08
Monocytes (10^3/μL)	0–2.38	0–0.99	0.19 ± 0.13	—	0.18–0.90	0.15 ± 0.11	0.16 ± 0.07
Basophils (10^3/μL)	0–0.21	0–0.18	0.05 ± 0.54	—	0.01–0.10	0.10 ± 0.07	0.0 ± 0.0
Platelets (10^3/μL)	298–931	178–777	729.58 ± 125.40		277–882	303 ± 133	437 ± 0.0
Reticulocytes (%)	—	—	2.1 ± 0.9	—	1–12	—	—

*Values are presented as a range or mean plus-or-minus standard deviation.
†Values for mink refer to although no statistical differences were determined between male and female minks.
‡International Species Information System: *Physiological data reference values*. Apple Valley, MN, 2002, ISIS.
MCH, Mean corpuscular hemoglobin; *MCHC*, mean corpuscular hemoglobin concentration; *MCV*, mean corpuscular volume.

TABLE 48-5

Reference Ranges for Serum Biochemical Parameters for Selected Mustelid Species

North American Parameter*	Nearctic River Otter	Eurasian Otter	Mink	Striped Skunk†	Ferret	Pine Marten	European Polecat†
Total protein, gram per deciliter (g/dL)	5.7–9.0	6.0–7.7	5.94 ± 0.31	6.2 ± 1.2	5.1–7.4	6.1 ± 7	5.7 ± 8
Albumin (g/dL)	2.4–4.1	1.25–3.6	2.98 ± 0.14	—	2.6–4.1	3.0 ± 4	3.3 ± 0.4
Globulin (g/dL)	2.9–5.8	2.7–4.8				3.1 ± 4	2.4 ± 0.7
Calcium (mg/dL)	6.8–10.0	5.2–10.3	9.54 ± 0.39	2.43 ± 0.23	8.0–11.8	9.2 ± 1.6	9.12 ± 0.92
Phosphorus (mg/dL)	3.2–8.3	4.2–8.7	5.29 ± 0.79	1.74 ± 0.61	4.0–9.1	4.95 ± 0.92	6.19 ± 1.70
Sodium, milliequivalent per liter (mEq/L)	136–158	142–158	153.7 ± 1.3	149 ± 7	137–162	155 ± 3	152 ± 6
Potassium (mEq/L)	3.5–5.3	3.9–5.7	4.34 ± 0.23	4.8 ± 0.7	4.3–7.7	4.0 ± 0.2	4.7 ± 0.6
Chloride (mEq/L)	94–121	102–125	114.5 ± 1.7	110 ± 6	102–125	126 ± 1	116 ± 8
Creatinine (mg/dL)	0.4–0.8	0.7–1.0	0.71 ± 0.08	1.09 ± 0.80	0.2–0.9	0.79 ± 0.18	0.49 ± 0.20
Urea nitrogen (mg/dL)	17–56	17.3–68.1	15.2 ± 5.6	33.9 ± 32.9	10–45	31.64 ± 11.2	12.5 ± 3.99
Cholesterol (mg/dL)	63–279	95–220		172.4 ± 103.8	64–296	176.9 ± 23.0	191.9 ± 52.6
Glucose (mg/dL)	56–225	51–400	125.8 ± 18.7	124.8 ± 62.9	62.5–207	314.5 ± 70.90	106.9 ± 28.9
SERUM ENZYMES							
Lactic acid dehydrogenase, international unit per liter (IU/L)	36–10,820	555–3,620	—	581 ± 323	—	1,875 ± 520	474 ± 403
Alkaline phosphatase (IU/L)	29–282	9.0–199	71.6 ± 56.9	70 ± 57	9–120	77 ± 29	64 ± 79
Gamma-glutamyl transferase (IU/L)	8–38	—	—	2 ± 3	—	—	10 ± 8
Creatine kinase (IU/L)	67–1,300	26–1,794	—	895 ± 252	—	555 ± 234	379 ± 384
Alanine aminotransferase (IU/L)	46–990	34–307	—	120 ± 98	82–289	173 ± 44	102 ± 56
Aspartate aminotransferase (IU/L)	34–1,260	71–328	67.0 ± 13.7	75 ± 22	28–248	159 ± 18	74 ± 28

*Values are presented as a range or mean plus-or-minus standard deviation.
†International Species Information System: *Physiological data reference values*. Apple Valley, MN, 2002, ISIS.

TABLE 48-6

Selected Infectious Diseases of Mustelids

Disease	Causative Agent	Epizootiology	Clinical Signs	Diagnosis	Management	Species Reported
Viral canine distemper	Canine distemper virus (Paramyxoviridae)	Transmission of the virus is most commonly accomplished by aerosol exposure or direct contact with conjunctival and nasal exudates, urine, feces, and skin	Weight loss, anorexia, hyperemia of the face and ears, hyperkeratosis of the nasal planum and footpads, and oculonasal discharge	Histopathology, immunofluorescent antibody (IFA) test on conjunctival smear	Vaccination with canary-pox recombinant canine distemper virus subunit vaccine (Purevax, Merial)	Domestic ferret, black footed ferret, American and Eurasian badger, weasel, striped skunk, Eurasian and American mink, sable, stone and pine marten, polecat, weasel, Nearctic river and Eurasian otter
Influenza	Orthomyxoviridae (several strains)	Transmission by inhalation of aerosol droplets	Sneezing, conjunctivitis, unilateral otitis, fever, photophobia	Clinical signs, presence of hemagglutination-inhibiting (HI) antibodies (hemagglutination inhibition test)	Prevention of exposure of susceptible animals to infected individuals (animals or caretakers) Antihistamine, antivirals, and antibiotics may be used	Domestic ferret and mink
Aleutian disease and plasmacytosis	Parvoviridae	Infected animals may serve as potential source of infection	Weight loss, hypergammaglobulinemia, reproductive failure, hemorrhagic enteritis, and immune-mediated glomerulonephritis	Hypergammaglobulinemia usually greater than 20% of total serum protein IFA test, counter immunoelectrophoresis test	No vaccine is available	Typically a disease of farm-raised mink, but has been found in feral mink, domestic ferret, and striped skunk
Ferret kit disease	Rotavirus	Affects kits May become enzootic in the facility	Watery diarrhea, anorexia, and lethargy	Negatively stained virus particles identified in fresh feces	Subcutaneous electrolyte solutions and oral antibiotics (spectinomycin, amoxicillin, and trimethoprim-sulfa)	Ferret
Bacterial salmonellosis	*Salmonella newport, Styphimurium, Scholerasuis, S. anatum, S. enteritidis, S. kentucky, S. hadar*	*Salmonella* spp. have been isolated in a number of clinically normal animals Associated to feeding with uncooked meat	Hemorrhagic enteritis, dehydration, loss of body weight, fever, and lethargy	Fecal culture	Supportive care and antibiotics	Many mustelids
Tuberculosis	*Mycobacterium* spp. *(M. bovis, M. avium-intracellulare, M. tuberculosis)*	Usually infected by eating *Mycobacterium*-contaminated meat	Weight loss, enlarged lymph nodes, chronic respiratory disease, mastitis	Direct examination of tissue, culture	Evaluate zoonotic potential in case of treatment	Mink, ferret, otters, and Eurasian badger

Campylobacteriosis	*Campylobacter jejuni, C. coli*	Ferrets may be asymptomatic carriers Raw meat diets may predispose mink to infection	Fever, leukocytosis, abortion, diarrhea	Fecal culture	Antimicrobials (erythromycin, amoxicillin and others)	Ferret, mink
Botulism	Type A, B, C, E *Clostridium botulinum*, and *C. perfringens* type A, *C. welchii*	Caused by eating uncooked or contaminated meat Associated with capture stress in wild otters	Animals are found dead or with paralysis, and dyspnea before dying Enterotoxemia, acute gastric distention, cyanosis	Fecal Gram stain, toxin assay	Prevention and treatment difficult Aggressive therapy	Otters, black-footed ferret
Pneumonia	*Pseudomonas aeruginosa, P. putrefaciens, S. zooepidemicus, S. pneumoniae, E. coli, Klebsiella pneumoniae, Bordetella bronchiseptica, Listeria monocytogenes*	Concurrent infection with calicivirus or picornavirus may predispose animal to infection	Dyspnea, cyanotic mucous membranes, increased lung sounds, nasal discharge, fever, lethargy, and anorexia	Clinical signs, complete blood count results (leukocytosis), culture, and cytologic findings	Supportive care, antimicrobial therapy according to test results Antibiotics to consider include trimethoprim-sulfa, and cephalosporins	Most mustelids
Anthrax	*Bacillus anthracis*		Acute death, with blood draining from body cavities	Staining smears of peripheral blood, postmortem lesions	Penicillin: streptomycin	Eurasian badger, honey badger, and mink
Fungal dermatomycosis	*Microsporum* sp. and *Trichophyton* sp.	Transmitted by direct contact or via fomites and is associated with overcrowding and exposure to cats	Skin and hair lesions similar to those reported in other species	Clinical signs are suspicious but diagnosis is made on the basis of a mycotic culture	Topical treatment with keratolytic shampoos, povidone-iodine scrubs, and antifungal medications (itraconazole, ketoconazole)	Most species

TABLE 48-7

Selected Parasitic Diseases of Mustelids

Parasite	Location in Host	Clinical Signs	Diagnosis	Management	Species Reported
Toxoplasma gondii	Multiple organs (disseminated)	Elevated rectal temperature, lymphadenitis, splenomegaly, myocarditis, pneumonitis, hepatitis, encephalitis	Serologic	Prevention Avoid contact with feline species and feline feces Treatment with pyrimethamine and sulfamerazine, others	Skunk, ferret, weasel, polecat, otters
Lung worms (*Crenosoma* spp., *Perostrongylus* spp., *Filaroides* spp., *Skrjabingylus* spp.)	Lung and sinus	Cachexia, anemia, coughing, dyspnea, depression, nasal discharge, and neurologic signs	Finding the ova or first stage infective larvae in fecal samples	Use of appropiate anthelmintic drug (ivermectin, fenbendazole, mebendazole)	Mink, skunk, sable, Eurasian badger, otter, ermine
Kidney worm (*Dioctophyma renale*)	Kidney (usually right kidney)	Weight loss, hematuria, polyuria, renal colic, and trembling	Finding of characteristic ova in urine, radiography or ultrasonography	Surgical treatment (removal of the parasitized kidney), fluid and antibiotic therapy	Mink, otter, weasel, ermine, marten, fisher, grison
Sarcoptic mange (*Sarcoptes scabiei*)	Skin (especially head and neck)	Scab formation around head and neck, tail, and feet In advanced cases, the entire body may be involved	Finding the mites in skin scraping or biopsy Diagnostic treatment with ivermectin	Ivermectin (0.3–0.4 milligram per kilogram [mg/kg]) as a single injection, or 0.2 mg/kg, orally (PO) every other day for 2 weeks if severe; antibiotics for secondary infection	Most mustelids
Fleas (most often *Ctenocephalides* sp.)		May be asymptomatic, pruritus and flea allergy dermatitis, with chronic scratching and rubbing Severe infestation may lead to debilitation by exsanguination	Visualization of fleas or flea defecations	Affected animals and enclosures should be repeatedly treated with suitable insecticides (pyrethrins, fibronil, imidacloprid [use small cat/kitten vial/dose], lufenuron)	Most mustelids

cats (pyrethrin powders and sprays and others). Organophosphates and carbamates should be used with caution, as safe protocols for mustelids have not been established.

Internal Parasites

Protozoal infection include *Giardia* spp., *Isospora* spp., *Eimeria* spp., *Sarcocystis* spp., *Toxoplasma gondii*, *Neospora caninum*, *Sarcosporidium* sp., *Besnoitia* spp., *Hepatozoon* spp., *Pneumocystis carinii*, *Trypanosomiasis cruzi*, *Cryptosporidium* spp.[40]

Helminths reported from mustelids in both zoos and from the wild include: lung flukes (*Paragonimus westermani* and *P. kellicotti*), intestinal fluke (*Nanophyetus salmincola, Troglotrema acutum*), liver flukes (*Fasciola hepatica*), *Acanthocephala* (*Corynsoma semerme, C. strumosum, Macracanthorhynchus ingens*), tapeworms (*Taenia* sp., *Monordotaenia* sp., *Oschmarenia* sp.), trichinosis (*Trichinella* sp.), lung worms (*Skrjabingylus* spp., *Crenosoma* spp., *Perostrongylus* spp., and *Filaroides* spp.), heartworms (*Dirofilaria* spp.), ascariasis (*Ascaris* spp., *Baylisascaris devosi, Toxocara canis*), *Dioctophyma renale, Dracunculus* spp., *Strongyloides* spp., *Capillaria hepatica, Uncinaria* sp., *Euyhelmis squamula, Aonthotheca putorii, Eucoleus* sp., *Pearsonema plica, Molineus patens*, and *Mastophorus muris*.

Table 48-8 lists common drugs and doses used for controlling parasitic diseases in mustelids.

Noninfectious Diseases

The following have been reported to affect wild and domestic mustelids (Table 48-9). Renal calculi (calcium oxalate and urate calculi) were detected in 66.1% of the captive North American adult population of Asian small-clawed otters that had been imaged or necropsied, and prevalence in wild-born otters was 76.7%. The captive diet appears to be a contributing factor to urolith formation and progression.[32] Other medical problems associated with nutrition and feeding practices in mustelids are hypovitaminosis A; vitamin E, thiamin, (Chastek disease), calcium, vitamin D, zinc, and biotin deficiencies; zinc toxicity; nutritional secondary hyperparathyroidism (NSH); fibrous osteodystrophy; gastric trichobezoars; dental disease (dental calculus, gingivitis, and periodontal disease); gastric and duodenal ulceration; and gastric dilatation and torsion.[34,36]

Metabolic Diseases

Urolithiasis (magnesium ammonium phosphate, calcium oxalate, calcium urate, calcium phosphate, and ammonium urate uroliths), hypocalcemia, pregnancy toxemia, agalactia, hyperestrogenism, hormonal alopecia, idiopathic hypersplenism, gastric dilatation and torsion (possibly associated with *Clostridium welchii*), dental and skeletal anomalies, periodontal disease, amyloidosis, hyperadrenocorticism (ferret), insulinoma (ferret), diabetes mellitus (ferret), fatty

TABLE 48-8

Parasiticides Recommended for Mustelids

Generic Name	Dosage (milligram per kilogram [mg/kg])	Route of Administration	Comments
Amprolium	19, every 24 hours	Orally (PO)	Coccidia
Carbaryl (0.5%) shampoo		Weekly for 3 weeks	Mange
Fenbendazole	50, for 3–5 days	Oral	Alternatively 20 mg/kg for 5 days
Fipronil	1 pump of spray or ⅕–½ of cat dose every 60 days	Topical	Flea adulticide
Ivermectin	0.2–0.5, repeat every 2 weeks if needed	Subcutaneous (SC) or PO	0.006 mg/kg, PO, monthly for heartworm prevention Ectoparasites and endoparasites
Levamisole	10	PO or SC	May be toxic at higher dosages
Mebendazole	50 mg/kg q12h × 2 days	PO	Nematodes
Metronidazole	15–20, every 12 hours for 2 weeks	PO	Protozoa: *Clostridium* spp.
Pyrethroids		—	Ectoparasites
Praziquantel	5–25, repeat in 2 weeks	PO or SC	Cestodes and trematodes
Propoxur	—	Topical	Ectoparasites
Pyantel pamoate	5–60, repeat in 14 days OR 4.4 mg/kg q2 weeks	PO	Nematodes
Sulfadimethoxin	20–50, every 12–24 hours	PO	Antiparasitic, coccidian antimicrobial
Thiacetarsemide	2.2, every 12 hours for 2 days	Intravenously (IV)	Heartworm adulticide Follow 3–4 weeks later with ivermectin Caution must be used

liver, cardiovascular calcification, osteomalacia, and degenerative joint disease.[11,37]

Neoplasia

Over 50 different neoplasms have been reported in the domestic ferret. Although no current consensus exists on the cause of the high prevalence of neoplasia in ferrets, several theories have been proposed: genetic predisposition, early neutering of ferrets at 5 to 6 weeks of age, lack of natural photoperiod or exposure to natural sunlight, diet, and infectious agents. However, neoplasms are not common in species other than ferrets and include: seminoma, leiomyoma, adenocarcinoma, pheochromocytoma, teratoma, lymphosarcoma, anal sac carcinoma, lymphoreticular tumor, bronchoalveolar carcinoma, thyroid carcinoma, malignant melanoma, and a tumor resembling Hodgkin disease.[6,7]

Miscellaneous Diseases

Reproductive toxicity (including decreased baculum weight, cryptorchidism, cystic vas deferens) in European otters exposed to polychlorinated biphenyls and polychlorinated dibenzo-*p*-dioxins; organophosphate and carbamate intoxication; mortality associated with melarsomine and petroleum residues; mercury toxicity; secondary exposure to rodenticide; shock; exertional myopathy (capture myopathy); trauma; intestinal volvulus; pneumoperitoneum; uterine torsion; interspecific aggression (especially following introductions); behavior problems (self-mutilation); cystic kidneys; dilated cardiomyopathy; cor pulmonale; intervertebral disk disease; osteoarthritis; tail alopecia syndrome; overgrowth of claws; oral, gastric, and intestinal foreign bodies; gastric and intestinal ulcers; pyometra; capture related injuries (mostly digit and tooth damage); pulmonary silicosis; fibrocartilaginous emboli; trauma (mostly associated with gunshots, vehicle encounters, and from traps); and hydrocephalus in European otter cubs have all been reported.[9,14,17,24,31]

REPRODUCTION

Important variations exist in the reproductive cycles among mustelids. Some data for representative species are listed in Table 48-10. Most mustelids are seasonal breeders, with the sea otter and the Eurasian otter being exceptions. The duration of the breeding season may vary from 1 month (African striped weasel) to 12 months (Eurasian badger). Some mustelids are polyestrous, and others are monoestrous. The duration of estrus ranges from 3 to 5 days to 5 to 8 weeks. Most males that have been studied have active spermatogenesis for only about 3 to 4 months in a year, although exceptions such as the Eurasian badger do exist. Mustelids may be either induced or spontaneous ovulators.

Many mustelids exhibit delayed implantation: sea otters, Nearctic river otters, hog badgers, American and Eurasian badgers, ratels, striped skunks, western spotted skunks, wolverines, all martens, ermines, long tail weasels, minks, and marbled polecats. In those species, embryo development proceeds to the blastocyst stage and then ceases. This period of blastocyst dormancy is called diapause and varies from a few weeks in minks and striped skunks to almost a year in the Eurasian badgers. Extensive studies have been conducted on the mechanisms that control embryonic diapause in three species of mustelids: minks (*Mustela vison*), Eurasian badgers (*Meles meles*), and western spotted skunks (*Spilogale gracilis*). Numerous investigators have speculated on the ecologic significance and selective pressures that might have favored the development of delayed implantation.[29]

Changes in photoperiods are known to alter the secretion of pituitary hormones and thus the onset and duration of breeding, puberty, and timing of implantation. In this way, photomanipulation has been used in some species. Adequate numbers of animals should be maintained for mating, but compatibility does not ensure reproductive success. If copulation or gestation does not occur, different pairings should be tried, but in some cases, animals that are not compatible during most of the year will often breed if introduced during estrus. For this, determining when females are in estrous may be crucial. Various methods for estrus detection have been proposed in different species, including behavioral changes, vulvar swelling, vaginal cytology, and fecal and urinary hormone analyses. In males, the testes enlarge during the breeding season. Pregnancy may be determined by urinary progesterone and conjugated estrogen levels, palpation, radiography (end of gestation period), and ultrasonography.[4]

TABLE 48-9

Selected Noninfectious Diseases of Mustelids

Disease	Etiology	Signs	Management	Prevention	Species Reported
Exertional myopathy	Often, associated to recently immobilized, captured, and transported wild animals	Vary with species Elevated body temperature, depression, lack of response to the environment, ataxia, weakness, dark colored urine, elevated renal and muscular serum enzymes	Treatment is rarely successful Selenium or vitamin E preparations given subcutaneously or intramuscularly, sodium bicarbonate balanced electrolyte solution, and nonsteroidal anti-inflammatories	Improve methods of capture or restraint Reduce stress and hyperthermia during animal handling	Badger, otter, black footed ferret
Urolithiasis	Magnesium ammonium phosphate, calcium oxalate, calcium urate, calcium phosphate, and ammonium urate Primary cause unknown Diet (?)	Normally unnoticeable Abdominal radiography and ultrasonography are the most important diagnostic tools Signs may be similar to those in dogs and cats	In some cases, surgery or lithotripsy may be considered	—	Mink, ferret, Eurasian otter, small-clawed otter
Petroleum pollution	Spilled petroleum oils (crude or fuel)	Animals look wet and chilled Lethargy, dermatitis, conjunctivitis, respiratory distress, dehydration, malnutrition, anemia, thermoregulatory dysfunction, diarrhea, and neurologic signs	Primarily symptomatic Warm intravenous, intraosseous, subcutaneous isotonic fluids, glucose, antibiotics, and glucocorticoids Good ventilation, flushing the eyes Hand or tube feeding may be required Monitor blood parameters	—	Any aquatic mustelid may be affected
Polychlorinated biphenyls (PCBs)	Accumulation of high level of PCBs, especially by fish eating species	Anorexia, bloody stools, hepatic liver, kidney degeneration, gastric ulcers, decreased baculum weight, feminization of males Population declines, reproductive complications and kit mortality	—	—	Effects diagnosed in mink, Eurasian otter, polecat; may affect any piscivore species
Amyloidosis	Deposition of amyloid (17 different proteins) either locally or systemically	Relate to the specific sites of amyloid deposition Histologic evaluation of tissues obtained by biopsy or at necropsy	Usually progressive. Treatment unsuccessful In humans, some trials include antibiotics, colchicine, and dimethyl sulfoxide	—	Beech marten, pine marten, mink, wolverine, Asian small-clawed otter
Thiamine deficiency	Thiaminase present in some fish (especially carp, bullhead, smelt, herring)	Anorexia, salivation, ataxia, incoordination, pupillary dilation, and sluggish reflexes	Parenteral thiamine administration	Supplement with thiamine in piscivores species	Mink and otter May be a problem in piscivores species
Self-mutilation	Agitation, cutaneous excoriation, hair loss, cutaneous hemorrhage, secondary bacterial infection	Observation, physical examination, skin scrapings for cytology, etc.	Buspirone 10 milligram per kilogram (mg/kg), orally (PO) twice daily for 18 months	Proper housing, diet, species pairings	American badger

TABLE 48-10

Some Reproductive Characteristics of Selected Mustelids

Parameter	Badger (American/ Eurasian)	Ferret, Black-Footed Ferret	Marten (Pine/Stone)	Mink (American; Eurasian)	Otter (Nearctic River; Eurasian)	Giant Otter	Skunk (Striped; Spotted)	Tayra	European Polecat	Common Weasel/Ermine	Wolverine
Gestation	8 months; 9–12 months	41–42 days; 42–43 days	9 months	40–70 days; 35–72 days	245–365 days; 63–63 days	65–70 days	In South, 59–77 days; in North, 230–350 days	63–70 days	40–42 days	34–37 days; 10 months	7–9 months
Delayed implantation	Yes	No	Yes	Yes	Yes/no	No	No/yes	No	No	No/yes	Yes
Litter size	1–7; 1–6	1–18; 1–6	2–5/2–7	3–10; 2–7	2–5; 2–4	1–5	2–10/2–9	2	4–6	4–7; 4–8	2–3
Mass at birth	90–98 grams (g); 5–85 g	8–10 g; unknown	30 g	6–12 g; unknown	100–120 g	170–230 g	32–35;22 g	75–95 g	7–12 g	0.9–2.3/2.6–4.2 g	80–100 g
Weaning	3 months	6–8 weeks; unknown	4 months	3 months	3–4 months	3–4 months	2 months	Unknown	1 month	60 days; unknown	3 months
Sexual maturity	1 year	4–8 months in first year	28 months	In first year	23–27 months; in 2–3 years	Unknown	10 months in first year	1.5–2 years	In first year	115–1150 days; unknown	In 2–3 years
Type estrus*	M; P	P; M	M; —	P; —	M; P	—	M; P	P		—; M	P
Teats (pairs)	4; 3		2	4	—; 2–3	—	5–7; 5	—	3–5	5; 4–5	2

**M*, Monoestrous; *P*, polyestrous.

In ferrets, continued high levels of estradiol from persistent estrus may lead to alopecia and bone marrow suppression, resulting in pancytopenia and even death, so nonbreeding females should be neutered.

Contraception

No specific recommendations for contraception exist for mustelids, and ovariohysterectomy, vasectomy, and castration are currently the safest permanent sterilization procedures of birth control. Melengestrol acetate hormone implants have been used successfully to prevent conception in mustelids. These should be removed after 2 years for one pregnancy, if possible, and are not recommended for more than a total of 4 years. The human contraceptive implant Norplant contains levonorgestrel, a synthetic progestin, and has been used to prevent pregnancy in the striped skunk. Depo-Provera injection (5 mg/kg every 2 months) has also been used. Although no data exist for mustelids, progestin contraceptives may be associated to progressive endometrial hyperplasia, resulting in infertility, infections, and sometimes uterine cancer in other carnivores. Deslorelin implants (gonadotropin-releasing hormone [GnRH] analogue) have been used as an alternative to melengestrol acetate.[1]

PREVENTIVE MEDICINE

Many of the clinical and surgical procedures used in dogs and cats are applied to mustelids. Specialized surgical procedures have been developed for some mustelid species.[20,28,38] Periodic examinations should include the following:

- Checking transponders and tattoos, and reapplication, if necessary
- Checking baseline physiologic parameters (weight, breeding status)
- Examination of the oral cavity
- Evaluation of the reproductive tract, whole body radiography
- Collecting blood for hematologic and biochemical evaluation
- Checking for heartworm in endemic areas using a heartworm enzyme-linked immunosorbent antigen assay test
- Serum banking
- Performing fecal examination for internal parasites (and administering anthelmintics, if necessary). Table 48-8 lists some of the antiparasitic drugs commonly used to treat mustelids. Other drugs (e.g., antibiotics) are dosed at rates for ferrets, dogs, and cats.[8]
- Updating vaccinations

Few viral diseases have been reported in mustelids, except ferrets, although they have been routinely vaccinated against a wide variety of viral diseases. Mustelids have varying susceptibility (species and exposure dependent) to feline panleukopenia, canine distemper, rabies, and leptospirosis.[10] Most authors recommend vaccination of mustelids against rabies and canine distemper. Safety and efficacy of modified live canine distemper vaccinations in exotic species of carnivores has been historically problematic because vaccine-induced distemper has occurred (e.g., a modified-live virus derived from chick embryo cell culture caused the death of four female black-footed ferrets [*Mustela nigripes*], or protection was not achieved). In the past, killed distemper vaccines have not provided longstanding protection in most species. A recombinant canarypox-vectored canine distemper vaccine (Purevax, Merial, Athens, GA) has been shown to be safe and efficacious and is the best choice for general mustelid protection against canine distemper virus.[41] If an alternative modified-live canine distemper vaccine is used, it should be given separately and not in multiple forms, since immunosuppression and other untoward vaccine interactions might lead to disease. Ferret or mink cell culture-derived modified-live vaccines should *never* be used in mustelids. A modified-live canine distemper vaccine of primate kidney tissue cell origin, Onderstepoort type, is available in the United States (Galaxy D; Schering-Plough Animal Health Corporation, Omaha, NE) and has been proven to be safe and efficacious in hybrid black-footed ferrets and Siberian polecats. The only vaccine approved by the U.S. Department of Agriculture (USDA) for ferrets, Fervac-D (United Vaccines, Madison, WI), which is an egg-adapted strain, has induced anaphylactoid and anaphylactic reactions in some mustelids, so its use is not recommended.

Vaccination schedules for nondomestic species are extrapolated from studies of the domestic dog. Neonates receiving colostrum should be vaccinated every 3 to 4 weeks between 6 and 16 weeks of age. Colostrum-deprived neonates should be given two vaccinations administered at a 3- to 4-weeks interval and starting at 2 weeks of age because maternal antibodies acquired in utero may be absent by 4 to 6 weeks of age. Data on maternal antibody interference with vaccination in ferrets suggest that a final canine distemper vaccine should be administered after 10 weeks of age.

If an animal has an adverse reaction to canine distemper vaccine, an antihistamine (e.g., diphenhydramine hydrochloride, 0.5–2 mg/kg, intravenously [IV] or intramuscularly [IM]) or, for severe reactions, epinephrine (20 microgram per kilogram [μg/kg], IV, IM, subcutaneously [SC], or intratracheally (IT]) should be administered and supportive care provided.

Mustelids are also vaccinated with a killed rabies vaccine (Imrab), although the efficacy of this vaccine has not been proven in exotic mustelids. Rabies should be given at 16 weeks of age to animals at risk of contracting rabies and given boosters annually thereafter.

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