ASSOCIATION OF ZOOS & AQUARIUMS

# MUSTELID
# (*Mustelidae*)
# CARE MANUAL

CREATED BY THE
**AZA Small Carnivore Taxon Advisory Group**
IN ASSOCIATION WITH THE
**AZA Animal Welfare Committee**

## Mustelid (Mustelidae) Care Manual

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**Cover Photo Credits:** Deb Arndt – wolverine; Peg Dwyer - fisher

This nutrition chapter is an excerpt from the complete Animal Care Manual available at the

Association of Zoos and Aquariums (AZA)'s website:

http://www.aza.org/animal-care-manuals/

Further information about diets and the nutrition of this and other species can be found at the

AZA's Nutrition Advisory Group (NAG)'s website:

http://nagonline.net

# Chapter 5. Nutrition

## 5.1 Nutritional Requirements

> **AZA Accreditation Standard**
>
> **(2.6.2)** A formal nutrition program is recommended to meet the behavioral and nutritional needs of all species and specimens within the collection.

A formal nutrition program is recommended to meet the behavioral and nutritional needs of all mustelids (AZA Accreditation Standard 2.6.2). Diets should be developed using the recommendations of nutritionists, the Nutrition Advisory Group's feeding guidelines (www.nagonline.net/feeding_guidelines.htm), and veterinarians as well as AZA Taxon Advisory Groups and Species Survival Plans®. Diet formulation criteria should address the animal's nutritional needs, feeding ecology, as well as individual and natural histories to ensure that species-specific feeding patterns and behaviors are stimulated.

Within the Mustelid family there is great variation in food habits. Some are strict carnivores (*Mustela*), reported to consume small terrestrial and aquatic vertebrates, invertebrates, birds, and eggs (Kruska 1990; Nowak 1999; Fernandez-Moran 2003). Some species are "largely carnivorous" omnivores (*Spilogale*, *Taxidea*, *Eira*), consuming primarily small vertebrates and invertebrates, but also fruits and berries (Verts 1967; Kruska 1990; Macdonald 1999; Fernandez-Moran 2003). Otters (not covered in this document) are primarily piscivorous, consuming aquatic vertebrates and invertebrates (Kruska 1990; Macdonald 1999; Fernandez-Moran 2003; AZA Small Carnivore TAG 2008).

**Digestive System Morphology and Physiology:** The stomach of mustelids is simple, characteristic of carnivores. Similar to procyonids and ursids, the distal segment of the intestine is marked only by a change in the mucosa, and there is no cecum present (Stephens & Hume 1995). The intestine of *Mustela vison* is approximately 3 times body length, with a short and simple hindgut (Stephens & Hume 1995). Transit time in mink has been observed to be 2-4 hours, and should be considered when designing feeding schedules (Leonard 1966). In general, the mustelid gastrointestinal tract is designed to process readily digestible diets, higher in protein and fat than carbohydrates and fiber. High levels of protein from plant sources have been associated with urolithiasis in mustelids, and are therefore undesirable (Fernandez-Moran 2003). Fish sources should be carefully monitored as some species are highly susceptible to Hg and PCB toxicity (e.g., mink) (J. Ogden, personal communication).

**Nutrient Requirements:** Although many of the items consumed by mustelids are known, the nutrient content of these items has not been completely characterized. Beyond this, diversity within the family's feeding ecology precludes species or even genera-specific target nutrient levels. Some work has been done to define target nutrient levels for mink (NRC 1982) and Asian small-clawed otters (*Aonyx cinereus*) (Maslanka & Crissey 1999), but it does not represent the entire family. The target nutrient levels established herein are based on some of this previous work, as well as that with well-studied carnivores, such as cats (NRC 2006; Legrand-Defretin & Munday 1993; AAFCO 1994), and omnivores, such as dogs (NRC 2006; AAFCO 1999), mink (NRC 1982), and foxes (NRC 1982). Ranges are provided to best describe the needs across a variety of genera, with the high ends of each range for growing and lactating animals. In most cases, they reflect the highest values reported. Based on the emphasis of foraging strategy of the genus or species in question, a range of target nutrient values has been provided for more omnivorous or more carnivorous individuals (see Table 9). These ranges are provided in comparison to the straight requirements of cats, mink, dogs, Arctic fox, and Asian small-clawed otter as reference comparisons. See Appendix G for descriptions of the nutrients listed in Table 9.

Table 9: Target nutrient ranges for baseline species (dry matter basis)

| **Nutrient** | More Omnivorous[1] Skunk and Tayra | More Carnivorous[2] Badger, Ferret, Fisher, Wolverine |
|---|---|---|
| Protein (%) | 17.5-26.0[1a] | 19.7-32.5[2a] |
| Fat (%) | 5-8.5 | 9.0-30 |
| Linoleic Acid (%) | 1.0-1.3 | 0.5-0.55 |
| Vitamin A (IU/g) | 0.5-5.9 | 2.44-10 |
| Vitamin D (IU/g) | 0.5-0.55 | 0.25-1.0 |
| Vitamin E (mg/kg) | 27-50 | 27-120 |
| Thiamin (mg/kg) | 1.0-2.25 | 1.0-5.6[2b] |
| Riboflavin (mg/kg) | 1.6-10.5 | 1.6-4.25 |
| Pantothenic acid (mg/kg) | 7.4-15.0 | 5.0-8.0 |
| Niacin (mg/kg) | 11.4-20.0 | 9.6-60 |
| Pyridoxine (mg/kg) | 1.0-1.8 | 1.6-4.0 |
| Folacin (mg/kg) | 0.18-0.5 | 0.2-1.3 |
| Biotin (mg/kg) | 0.1-0.12 | 0.07-0.12 |
| Vitamin $B_{12}$ (mg/kg) | 0.022-0.035 | 0.02-0.035 |
| Calcium (%) | 0.5-1.2[1b] | 0.5-1.0[2c] |
| Phosphorus (%) | 0.5-1.0[1b] | 0.5-0.8[2c] |
| Potassium (%) | 0.4-0.6 | 0.4-0.6 |
| Sodium (%) | 0.04-0.3 | 0.05-0.4 |
| Magnesium (%) | 0.04-0.06 | 0.03-0.08 |
| Iron (mg/kg) | 30-90 | 80-114 |
| Zinc (mg/kg) | 50-120 | 50-94 |
| Copper (mg/kg) | 6.0-12.4 | 5.0-8.8 |
| Iodine (mg/kg) | 0.9-1.54 | 0.35-2.2 |
| Selenium (mg/kg) | 0.1-0.35 | 0.1-0.4 |

[1]Dog NRC (2006), Dog AAFCO (1999) (All numbers are based on requirement set for maintenance); Mink NRC (1982); Fox NRC (1982) (for mink and fox NRC protein is range of growth and maintenance, vitamins are for growth, and minerals for growth and maintenance).

[1a] Dog NRC (2006) suggests 10% protein for maintenance, but this is lower than would be recommended for all animals covered by the ACM.

[1b] Authors of this chapter would caution feeding diets with 0.3% calcium and/or phosphorus as the Dog NRC (2006) suggests, thus a more reasonable minimum value is recommended.

[2] Cat NRC (2006), Legrand-Defretin & Munday (1993), Cat AAFCO (1994); Maslanka & Crissey (1999); Mink NRC (1982); Fox NRC (1982) (for mink and fox NRC protein is range of growth and maintenance, vitamins are for growth, and minerals for growth and maintenance).

[2a] Lewington (2002) indicated that lactation demand on female mink (*Mustela*) may require up to 45.7% CP on a dry matter basis (based on a calculated 83% protein digestibility).

[2b]Blomqvist (2001) has indicated that wolverines (*Gulo gulo*) may have a higher requirement for thiamin than other mustelids. Thiamin and Vitamin E should be supplemented in all diets where frozen/thawed fish comprise more than 33% of the total diet.

[2c] Authors of this chapter would caution feeding diets with 0.29% calcium and 0.26% phosphorus as the Cat NRC (2006) suggests, thus a more reasonable minumim value is recommended.

All carnivores are highly susceptible to metabolic bone disease (Kaufman 1978) and other classic nutrition deficiency diseases (Wallach & Boever 1983). High-quality balanced diets should be fed to all of these species. Several factors affect nutrient requirements. These factors include: age, physiological state, health status, environment, activity and group dynamics. The target nutrient values in these standard recommendations encompass the needs for maintenance of adults, reproducing animals (gestation and lactation), as well as needs for growing animals. The sample diets provided in section 5.2 have supported all life stages.

Kits and juveniles: Young martens will begin eating solid food at about 36-45 days and are weaned at about 6 weeks of age (Martin 1996). Badger cubs can begin weaning at 8-19 weeks of age. At this time baby foods, scrambled eggs, minced meat, or day old chicks should gradually be included in the diet.

Weaning should be completed by 3 months of age, but may take longer for some individuals (Kidner 1995: cited in Newman et al. 2004). For information on hand-rearing formulas, see Chapter 7, section 7.5.

Reproductive status: Maintaining adequate weight is especially important in breeding females, as both obesity and poor body condition can lead to fertility problems. Pregnant and lactating females may require higher caloric and calcium intake. Amounts offered to gestating and lactating females should be closely monitored to allow for maintenance of fetal development, appropriate weight gain, and maintenance of body stores during lactation that supports adequate kit growth. It has been shown that the feeding of large pieces of meat every second day increases the breeding success of wolverines (Blomqvist 2001). When offering any diet item it should be a part of a nutritionally complete diet (nutrient content compared to target nutrient values in Table 9). There has been speculation that a delay in puberty of *Martes* species both in the wild and in zoos and aquariums may be due to nutritional deficiencies (Martin 1996).

Seasonal changes: Some of the mustelids will undergo a physiological response to decreasing temperatures; examples of this are the badger, which shows a reduced level of food intake in winter (Kruuk 1989), and the striped skunk, which also may become sluggish during the winter (Hindmarsh 1995). For fisher, an increase in dietary fruit (apples in particular) should be considered in the winter to mimic a natural dietary shift documented in at least a portion of their range (Arthur et al 1989).

There may be seasons when consumption is depressed (*Mephitis*, *Taxidea*), and others when food is readily and quickly consumed, thus development of individual standard and predictable feeding behavior patterns based on seasons can serve as effective diet management tools. Exact guidelines for what is considered acceptable seasonal weight gain are not available. In general, each individual should be monitored over the course of a year to establish their normal weight and body condition. A seasonal weight gain of no more than 10-30% of their base body weight can serve as a beginning target until each individual's ideal seasonal weights are determined.

Fisher, badger, and striped skunk are some of the mustelids known to store body fat seasonally during the winter (Kruuk 1989; Hindmarsh 1995; Martin 1996); this physiological change should be allowed while still monitoring the animals for excessive weight gain. Skunks and badgers show a tendency to put on weight in the fall and care should be taken that they are not overfed (Hindmarsh 1995; Hancox 1995). American badgers in the wild show ~33% more body fat in the fall than expected which begins to decrease from that time through March (Harlow 1981a and b). Fishers may add seasonal body fat stores (Powell 1979); weasels and stoats are not known for putting on winter fat (King 1989). How important seasonal weight changes are physiologically to the long-term health of these species is unknown, and if seasonal weight gain is part of the management strategy, subsequent seasonal weight loss should also be part of the plan.

**Energy Requirements:** Available information suggests that energy requirements are closely related to body mass, food habits, climate, and activity level, but these factors are all interrelated and some exert more influence than others. Mustelids, for the most part, have higher than predicted rates of basal metabolism compared to the Kleiber curve (McNab 1989). Basal metabolic rates are not species constant, and will be higher (as much as twice) for growing individuals than for adults (Robbins 1993). Gross energy requirements can be calculated using appropriate equations (Nagy et al 1998; KJ/d = 2.23 BWg ^ 0.85 for carnivorous mammals), but mustelid-specific equations are not readily available. Table 10 provides a listing of energy requirements for American mink.

Some individuals have a tendency toward obesity and should receive proportionately less food. Each genus, or species, will require a specific diet that may vary seasonally (e.g., mink may need higher dietary fat in winter) (Lewington 2002), and all diets should be thoroughly researched prior to animal acquisition. An animal's feeding ecology, target nutrient values, target body condition, available foods, and diets used by facilities already housing a species should all be considered when establishing a species' diet.

Table 10: Nutrition and energy requirements for American mink as percentage or amount per kg of dry matter (from Lewington 2002)

| Constituent | Growth | | Maintenance (mature) | Gestation | Lactation |
|---|---|---|---|---|---|
| | Weaning to 13 weeks | 13 weeks to maturity | | | |
| Energy | | | | | |
| Males (kcal ME)[a] | 4080 | 4080 | 3600 | --- | --- |
| Females (kcal ME) | 3930 | 3930 | 3600 | 3930 | 4500 |
| Crude protein (%) | 38[b] | 32.6-38.0 | 21.8-26.0 | 38 | 45.7 |
| Fat-soluble vitamins | | | | | |
| Vitamin A (IU) | 5.930 | [c] | [c] | [c] | [c] |
| Vitamin E (mg) | 27 | [c] | [c] | [c] | [c] |
| Water-soluble vitamins | | | | | |
| Thiamine (mg) | 1.3 | [c] | [c] | [c] | [c] |
| Riboflavin (mg) | 1.6 | [c] | [c] | [c] | [c] |
| Pantothenic acid (mg) | 8.0 | [c] | [c] | [c] | [c] |
| Vitamin B6 (mg) | 1.6 | [c] | [c] | [c] | [c] |
| Niacin (mg) | 20.0 | [c] | [c] | [c] | [c] |
| Folic acid (mg) | 0.5[d] | [c] | [c] | [c] | [c] |
| Biotin (mg) | 0.12 | [c] | [c] | [c] | [c] |
| Vitamin B12 (µg) | 32.6 | [c] | [c] | [c] | [c] |
| Minerals | | | | | |
| Calcium (%) | 0.4 | 0.4 | 0.3 | 0.4 | 0.6 |
| Phosphorus (%) | 0.4 | 0.4 | 0.3 | 0.4 | 0.6 |
| Ca:P ratio | 1:1-2:1 | 1:1-2:1 | 1:1-2:1 | 1:1-2:1 | 1:1-2:1 |
| Salt (%) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

[a] E: gross energy; ME: metabolizable energy. Nutrient requirements are based on an energy level of 5300kcal E or 4080kcal ME.
[b] Based on average quality protein with calculated digestibility of 83%. Higher quality protein and higher digestibility decrease the requirement; lower quality protein and lower digestibility increase the requirement.
[c] Quantitative requirements of minerals and vitamins not determined but dietary need has been demonstrated.
[d] May not be the minimum but this level is known to be adequate.

Work done by Muñoz-Garcia and Williams (2005) on the basal metabolic rate (BMR) of 58 Carnivora species indicated, after controlling for body mass, a strong correlation between home range size (used as a proxy for level of activity), diet, and BMR (Table 11). Based upon this work Muñoz-Garcia and Williams (2005) concluded that "…species that eat meat have larger home ranges and higher BMR than species that eat vegetable matter."

Table 11: Basal Metabolic Rate (BMR) of selected Mustelidae species (from: Muñoz-Garcia & Williams (2005), citing original sources)

| Species | Body Mass (g) | BMR (kJ/d) | Diet (%) (Meat/Invert/Veg) | Home range ($km^2$) (females only) |
|---|---|---|---|---|
| *Spilogale putorius* | 624 | 140.77 | 50/50/0 | 1.5 |
| *Lutra lutra* | 8,854.3 ± 1,777 | 2,997.3 ± 869 | 97.5/2.5/0 | 19.2 |
| *Meles meles* | 10,715.2 | 1,323 | 13.5/62.2/24.3 | 12.4 |
| *Taxidea taxus* | 9,000 | 1,301.2 | 49/6.8/44.2 | 3.1 |
| *Gulo gulo* | 13,133.4 ± 3,593 | 2,590.6 ± 445 | 100/0/0 | 207.5 |
| *Eira barbara* | 2,950 | 586.22 | 69.3/10/21 | 16.03 |
| *Martes americana* | 1,038 | 329.34 ± 30 | 99/0.5/0.5 | 15.15 |
| *Martes martes* | 930.6 | 362.3 | 77.3/11.3/11.4 | 1.49 |
| *Martes vison* | 834.9 | 283.6 | 58.5/41.5/0 | 2.9 |
| *Mustela frenata* (females) | 153 ± 3 | 84.35 ± 12 | 100/0/0 | 0.52 |
| *Mustela erminea* | 169.6 | 146.5 | 91.5/0.5/8 | 0.04 |
| *Mustela nivalis* | 72.6 | 87.3 | 97.3/1.8/0.9 | 0.58 |

## 5.2 Diets

The formulation, preparation, and delivery of all diets must be of a quality and quantity suitable to meet the mustelid's psychological and behavioral needs (AZA Accreditation Standard 2.6.3). Food should be purchased from reliable, sustainable and well-managed sources. Nutritional analyses should be routinely performed on the diet ingredients and results compared to previous and reported values. Based on food type, microbiological testing as part of an established quality control monitoring program also may be appropriate.

**AZA Accreditation Standard**

**(2.6.3)** Animal diets must be of a quality and quantity suitable for each animal's nutritional and psychological needs. Diet formulations and records of analysis of appropriate feed items should be maintained and may be examined by the Visiting Committee. Animal food, especially seafood products, should be purchased from reliable sources that are sustainable and/or well managed.

Food preparation must be performed in accordance with all relevant federal, state, or local regulations (AZA Accreditation Standard 2.6.1). Meat processed on site must be processed following all USDA standards.

**AZA Accreditation Standard**

**(2.6.1)** Animal food preparations must meet all local, state/provincial, and federal regulations.

If browse plants are used within the animal's diet or for enrichment, all plants must be identified and assessed for safety. The responsibility for approval of plants and oversight of the program should be assigned to at least one qualified individual (AZA Accreditation Standard 2.6.4). The program should identify if the plants have been treated with any chemicals or near any point sources of pollution and if the plants are safe for the species. If animals have access to plants in and around their exhibits, there should be a staff member responsible for ensuring that toxic plants are not available. Typically browse is not a dietary item for mustelid species. However, all plant items used in or around exhibits or those used for enrichment should be cleared by institutional management including the veterinarian, nutritionist and horticulturist. If there are any questions regarding the safety of a plant it should not be used.

**AZA Accreditation Standard**

**(2.6.4)** The institution should assign at least one person to oversee appropriate browse material for the collection.

**Diet Composition:** Most mustelids are easily maintained on commercially available, nutritionally complete meat diets, to which dry dog food, cat food, trout chow, fish, meat, or cereal is added (these additives are species-specific, and should not be viewed as inter-changeable) (Siegmund 1973; Wallach & Boever 1983; Fernandez-Moran 2003). Omnivorous mustelids need a broader spectrum diet. Whole animal carcasses (rodents, rabbits, birds, fish), freshly killed and thawed, may be substituted for part of the diet. Whole foods of this type need to be calculated into the overall nutritional content of the diet; care

should be taken to ensure proper nutritional balance and that whole carcass foods come from reliable, disease-free sources. Invertebrates may be substituted in diets of small species, and fruits and vegetables (e.g., apples, bananas, berries, and other seasonal fruits) offered as part of a balanced diet to both omnivorous and carnivorous (*Martes* sp.) species (Moore 1997; Fernandez-Moran 2003).

**Sample Diets:** There is a wide range of diets that can be appropriate for mustelids (Table 12). For the more carnivorous members of the family (*Mustela*), commercially prepared, nutritionally complete, meat diets, vertebrate and invertebrate whole prey items, fish, and wet/dry nutritionally complete food items can be used to formulate diets which meet target nutrient levels (see Table 9). For the more omnivorous members (*Mephitis*, *Spilogale*), diets that contain a mix of food items and groups appear most appropriate. It is important to keep in mind that the nutrient content of all items consumed in the diet (whole prey, meat mixes, bones, nutritionally complete foods, invertebrates, etc) should be known and included in the nutrient analysis of the diet. This will help maintain a diet that meets nutrient needs and avoids incidence of metabolic problems (metabolic bone disease, obesity, anorexia, etc). For a summary of the nutritional composition of whole prey items, refer to the "Nutrient Composition of Whole Vertebrate Prey (Excluding Fish) Fed in Zoos" (Dierenfeld et al. 2002).

In these guidelines, sample diets are provided as examples only. The goal is to provide a diet that meets target nutrient values and is readily consumed. See Table 13 for a comparison of sample diets to recommended nutrient values. Ideally, a palatable nutritionally complete food item (which would include some commercial meat mixes) should be used as the base of the diet to which can be added vertebrate and invertebrate prey, and produce (fruits, berries, etc) as appropriate, based on feeding strategy. Offering hard food items will encourage tooth abrasion and promote dental health.

Fish also contain high levels of polyunsaturated fatty acids (PUFAs) that oxidize quite readily and can lead to vitamin E deficiency. Steatitis (yellow fat disease) has been reported in mink that were fed diets high in PUFAs (McDowell 2000). Engelhardt & Geraci (1978) and Bernard et al. (1997) suggest adding 400mg/kg DM vitamin E to the diets of animals consuming fish or other items high in PUFAs.

Table 12: Sample diets from AZA institutions for mustelid species (as fed)*

| Species | Common Name | Institution | Food Item[1] | Grams/day | % in diet |
|---|---|---|---|---|---|
| *Martes pennant* | Fisher | Institution A | Milliken Meat Feline | 235 | 89.4 |
| | | | Mice – 2 times per week | 9.1 | 3.5 |
| | | | Chicks – 2 times per week | 10.6 | 4.0 |
| | | | Egg, Hard-boiled | 8.3 | 3.1 |
| | | | Bones – small beef or lamb 1x/wk | | |
| | | | Total | 263 | 100 |
| | | Institution B 1.0 | Nebraska Feline Diet | 306 | 73.6 |
| | | | Hills Science Feline Mature | 34.3 | 8.2 |
| | | | Carrot or Yam | 51.4 | 12.3 |
| | | | Whole body – elk, bison, fish, rat, mouse etc. | 23.6 | 5.7 |
| | | | Mazuri Carnivore Vitamin | 0.75 | 0.2 |
| | | | Bone – 1 x/wk | | |
| | | | Total | 415.4 | 100 |
| | | Institution B 0.1 | Nebraska Feline Diet | 139.3 | 58.9 |
| | | | Hills Science Feline Mature | 34.3 | 14.5 |
| | | | Carrot or Yam | 51.4 | 21.7 |
| | | | Whole body – elk, bison, fish, rat, mouse etc. | 10.7 | 4.5 |
| | | | Mazuri Carnivore Vitamin | 0.75 | 0.3 |
| | | | Bone – 1 x/wk | | |
| | | | Total | 236.4 | 100 |
| *Gulo gulo* | Wolverine | Institution A | Milliken Meat Feline | 400 | 83.7 |
| | | | Mice – 2 times per week | 9.1 | 1.9 |
| | | | Chicks – 2 times per week | 10.6 | 2.2 |
| | | | Egg, Hard-boiled | 8.3 | 1.7 |
| | | | Hill's Science Senior Dog Food dry | 50 | 10.5 |
| | | | Bones – Nebraska Brand beef – 1x/wk | | |
| | | | Total | 478 | 100 |
| | | Institution B | Nebraska Feline Diet | 585 | 79.7 |
| | | | Hills Science Feline Mature | 51.4 | 7.0 |
| | | | Carrot or Yam | 51.4 | 6.1 |
| | | | Whole body – elk, bison, fish, rat, mouse etc. | 45.0 | 7.0 |
| | | | Mazuri Carnivore Vitamin | 150 | 0.2 |
| | | | Bone – 1 x/wk | | |
| | | | Total | 882.8 | 100 |
| | | Institution C | Natural Balance Beef 10% fat | 636 | 75.4 |
| | | | Lake Smelt | 130 | 15.4 |
| | | | Capelin | 26 | 3.1 |
| | | | Herring | 26 | 3.1 |
| | | | Rats | 26 | 3.1 |
| | | | Small bones – beef rib bones | | |
| | | | Total | 844 | 100 |
| | | Institution D | Natural Balance Beef 10% fat | 681 | 95.5 |
| | | | Mackerel – 1 each Friday | 28.6 | 4.0 |
| | | | Mice – avg. 25 grams | 3.6 | 0.5 |
| | | | Bones – small non-meaty | | |
| | | | Total | 713.2 | 100 |
| *Taxidea taxus* | Badger | Institution E | Natural Balance Beef 5% fat | 86 | 50.6 |
| | | | Premium Edge Adult Chicken/Rice/Veg | 44 | 25.9 |
| | | | Mealworms | 7 | 4.1 |
| | | | Crickets | 7 | 4.1 |
| | | | Fruit – rotated used apple | 14 | 8.2 |
| | | | Vegetable – rotated used yam | 12 | 7.1 |
| | | | Total | 170 | 100 |
| | | Institution F | Natural Balance Beef 5% fat | 85 | 5.3 |
| | | | IAMS Weight Control Cat dry | 142 | 8.9 |
| | | | Mouse – avg. 22.5 | 22.5 | 1.4 |
| | | | Rabbit – 1 kg | 1000 | 62.9 |
| | | | Root Vegetable used sweet potato | 340 | 21.4 |

| Species | Common Name | Institution | Food Item[1] | Grams/day | % in diet |
|---|---|---|---|---|---|
| | | | Total | 1589 | 100 |
| | | Institution G | Nebraska Brand Feline | 48.6 | 21.9 |
| | | | Mice | 34.3 | 15.4 |
| | | | Egg, Hard-boiled | 12.8 | 5.8 |
| | | | Rat, small | 23.6 | 10.6 |
| | | | ZuPreem Feline canned | 24.4 | 11.0 |
| | | | Trout | 21.4 | 9.6 |
| | | | Produce – rotated used apple | 57.0 | 25.7 |
| | | | Total | 222.1 | 100 |
| | | Institution B | Hills Science Feline Mature dry | 114 | 55.9 |
| | | | Nebraska Brand Feline Diet | 60 | 29.4 |
| | | | Apple | 30 | 14.7 |
| | | | Total | 204 | 100 |
| *Mustela putorius furo* | Domestic Ferret | Institution F | IAMS regular dry cat food | 45 | 57.0 |
| | | | Banana with peel | 10 | 12.7 |
| | | | Vegetables – assorted | 24 | 30.4 |
| | | | Total | 79 | 100 |
| | | Institution H | Hills Science Diet Light Adult Cat Food | 25 | 100 |
| | | Institution I | Mazuri Ferret Diet | 50 | 100 |
| *Mephitis mephitis* | Skunk | Institution J | PMI Premium 22 Dog Food[1] | 21 | 37 |
| | | | Old Mother Hubbard Canned Cat Food[2] | 21 | 37 |
| | | | Fruit | 12 | 23 |
| | | | Other | 1.3 | 3 |
| | | | Total | 145 | 100 |
| | | Institution K | IAMS weight control cat dry | 8.5 | 10.2 |
| | | | Yogurt, low-fat | 20 | 24.0 |
| | | | Vegetables, frozen mixed | 13.2 | 15.9 |
| | | | Eukanuba reduced calorie dog dry | 8.5 | 10.2 |
| | | | Banana | 12 | 14.4 |
| | | | Apple | 12 | 14.4 |
| | | | Grape | 9 | 10.8 |
| | | | Total | 83.2 | 100 |
| | | Institution A | Hills Science Diet Maintenance | 20 | 8.3 |
| | | | Vegetables, frozen mixed | 145 | 60.4 |
| | | | Fruit – rotated used apple | 35 | 14.6 |
| | | | Cottage cheese | 20 | 8.6 |
| | | | Yogurt | 20 | 8.6 |
| | | | Total | 240 | 100 |
| | | Institution B | Hills Science Canine Light dry | 40 | 64.3 |
| | | | Vegetables used carrot | 12 | 19.2 |
| | | | Fruit used apple | 10 | 16.1 |
| | | | Salmon Oil | 0.25 | 0.40 |
| | | | Total | 62.25 | 100 |
| *Eira barbara* | Tayra | Institution L | Nebraska Brand Canine Diet | 113 | 23.3 |
| | | | Mazuri Ferret | 157 | 32.3 |
| | | | Banana | 57 | 11.8 |
| | | | Apple | 57 | 11.8 |
| | | | Sweet Potato | 57 | 11.8 |
| | | | Mice | 22.5 | 4.6 |
| | | | Egg, hard-boiled | 16.9 | 3.5 |
| | | | Chick | 4.6 | 0.9 |
| | | | Bone – small rib 2x/wk | | |
| | | | Total | 485 | 100 |
| | | Institution K | ZuPreem Feline canned | 187 | 28 |
| | | | Mazuri Omnivore biscuit | 79 | 12 |
| | | | Fruit – rotated used apple | 233 | 35 |
| | | | Carrot, cooked | 67 | 10 |
| | | | Sweet Potato, cooked | 67 | 10 |

| Species | Common Name | Institution | Food Item[1] | Grams/day | % in diet |
|---|---|---|---|---|---|
| | a | | Mice | 34 | 5 |
| | | | Total | 667 | 100 |

[1] Milliken Meats Products, LTD. Scarborough, Ontario Canada M1V 3P1; Central Nebraska Packing, Inc. North Platte, NE 69103; Hill's Pet Nutrition, Inc. Topeka, KS 66603; PMI Nutrition International. Brentwood, MO 63144; Natural Balance Pet Foods, Inc. Pacoima, CA 91331; Premium Edge Brand® Meta, MO 65058; P&G Pet Care (IAMS), Cincinnati, OH 45220; Zupreem; Shawnee, KS 66214; Old Mother Hubbard, Lowell, MA 01853.
* The AZA SCTAG does not specifically endorse the use of any mentioned products

The nutrient content of these sample diets compared to the target nutrient levels described in Table 12 are provided in Table 13.

Table 13: Nutrient content of sample diets[1] (dry matter basis)

| Nutrient | Institution A Fisher | Institution B 1.0 Fisher | InstitutionB 0.1 Fisher | More Carnivorous |
|---|---|---|---|---|
| Protein (%) | 63.6 | 41.9 | 38.2 | 19.7-32.5 |
| Fat (%) | 16.7 | 34.3 | 30.3 | 9.0-30 |
| Vitamin A (IU/g) | 33.6 | 54.2 | 82.1 | 2.44-10 |
| Vitamin D (IU/g) | 0.87 | 0.74 | 0.57 | 0.25-1.0 |
| Vitamin E (mg/kg) | 283 | 278 | 215 | 27-120 |
| Thiamin (mg/kg) | 0.55[2] | 8.5 | 6.8 | 1.0-5.6 |
| Riboflavin (mg/kg) | 0.53[2] | 0.05 | 0.04 | 1.6-4.25 |
| Pantothenic acid (mg/kg) | 1.45[2] | 0.19[2] | 0.30[2] | 5.0-8.0 |
| Niacin (mg/kg) | 0.07[2] | 2.4[2] | 4.06[2] | 9.6-60 |
| Pyridoxine (mg/kg) | 0.13[2] | 0.71[2] | 1.19[2] | 1.6-4.0 |
| Folacin (mg/kg) | 0.05[2] | 0.07[2] | 0.12[2] | 0.2-1.3 |
| Biotin (mg/kg) | [2] | [2] | [2] | 0.07-0.12 |
| Vitamin $B_{12}$ (mg/kg) | 0.07 | 0.05 | 0.05 | 0.02-0.035 |
| Calcium (%) | 1.54 | 1.6 | 1.5 | 0.5-1.0 |
| Phosphorus (%) | 1.38 | 1.1 | 1.0 | 0.5-0.8 |
| Potassium (%) | 0.82 | 0.93 | 0.98 | 0.4-0.6 |
| Sodium (%) | 0.35 | 0.49 | 0.44 | 0.05-0.4 |
| Magnesium (%) | 0.08 | 0.11 | 0.10 | 0.03-0.08 |
| Iron (mg/kg) | 332 | 152 | 118 | 80-114 |
| Zinc (mg/kg) | 120 | 65.4 | 50.6 | 50-94 |
| Copper (mg/kg) | 4.05 | 7.2 | 5.82 | 5.0-8.8 |
| Iodine (mg/kg) | [2] | 0.02[2] | 0.03[2] | 0.35-2.2 |
| Selenium (mg/kg) | 0.03[2] | 0.36 | 0.28 | 0.1-0.4 |

| Nutrient | Institution A Wolverine | Institution B Wolverine | Institution C Wolverine | Institution D Wolverine | More Carnivorous |
|---|---|---|---|---|---|
| Protein (%) | 52.5 | 43.4 | 53.7 | 51.8 | 19.7-32.5 |
| Fat (%) | 16.0 | 35.9 | 28.1 | 28.4 | 9.0-30 |
| Vitamin A (IU/g) | 21.7 | 36.1 | 14.0 | 14.9 | 2.44-10 |
| Vitamin D (IU/g) | 0.68 | 0.79 | 1.3 | 1.5 | 0.25-1.0 |
| Vitamin E (mg/kg) | 383 | 299 | 311 | 359 | 27-120 |
| Thiamin (mg/kg) | 0.25[2] | 8.9 | 9.1 | 10.6 | 1.0-5.6 |
| Riboflavin (mg/kg) | 0.24[2] | 0.13[2] | 15.8 | 18.5 | 1.6-4.25 |
| Pantothenic acid (mg/kg) | 0.65[2] | 0.73[2] | 28.6 | 33.6 | 5.0-8.0 |
| Niacin (mg/kg) | 0.03[2] | 1.46[2] | 120 | 141 | 9.6-60 |
| Pyridoxine (mg/kg) | 0.06[2] | 0.42[2] | 11.2 | 13.1 | 1.6-4.0 |
| Folacin (mg/kg) | 0.02[2] | 0.05[2] | 25.1 | 29.4 | 0.2-1.3 |
| Biotin (mg/kg) | [2] | [2] | 1.5 | 1.7 | 0.07-0.12 |
| Vitamin $B_{12}$ (mg/kg) | [2] | 0.06 | 0.11 | 0.13 | 0.02-0.035 |
| Calcium (%) | 1.32 | 1.6 | 1.8 | 1.8 | 0.5-1.0 |
| Phosphorus (%) | 1.20 | 1.2 | 1.0 | 1.0 | 0.5-0.8 |
| Potassium (%) | 0.84 | 0.88 | 0.46 | 0.34 | 0.4-0.6 |
| Sodium (%) | 0.32 | 0.50 | 1.0 | 1.1 | 0.05-0.4 |
| Magnesium (%) | 0.09 | 0.12 | 0.33 | 0.36 | 0.03-0.08 |
| Iron (mg/kg) | 252 | 163 | 136 | 145 | 80-114 |
| Zinc (mg/kg) | 90.8 | 70.0 | 192 | 211 | 50-94 |
| Copper (mg/kg) | 2.9[2] | 7.5 | 17.1 | 18.9 | 5.0-8.8 |
| Iodine (mg/kg) | [2] | 0.02[2] | 0.70 | 0.82 | 0.35-2.2 |
| Selenium (mg/kg) | 0.01[2] | 0.39 | 0.19 | | 0.1-0.4 |

| Nutrient | Institution E Badger | Institution F Badger | Institution G Badger | Institution B Badger | More Carnivorous |
|---|---|---|---|---|---|
| Protein (%) | 39.3 | 47.8 | 35.4 | 34.9 | 19.7-32.5 |
| Fat (%) | 16.8 | 12.7 | 23.7 | 25.4 | 9.0-30 |
| Vitamin A (IU/g) | 5.6 | 135 | 1.25 | 1.9 | 2.44-10 |
| Vitamin D (IU/g) | 0.61 | 0.79 | 0.19[2] | 0.18[2] | 0.25-1.0 |
| Vitamin E (mg/kg) | 305 | 74.9 | 15.7[2] | 67.9 | 27-120 |
| Thiamin (mg/kg) | 5.5 | 8.2 | 1.9[2] | 2.0 | 1.0-5.6 |
| Riboflavin (mg/kg) | 9.0 | 6.7 | 1.9[2] | 0.03[2] | 1.6-4.25 |
| Pantothenic acid (mg/kg) | 21.5 | 16.9 | 3.4[2] | 0.14[2] | 5.0-8.0 |
| Niacin (mg/kg) | 105 | 58.0 | 7.5[2] | 0.17[2] | 9.6-60 |
| Pyridoxine (mg/kg) | 6.9 | 7.7 | 0.76[2] | 0.11[2] | 1.6-4.0 |
| Folacin (mg/kg) | 0.16 | 0.82 | 0.14[2] | 0.01[2] | 0.2-1.3 |
| Biotin (mg/kg) | 0.64 | 0.30 | 0.09 | [2] | 0.07-0.12 |
| Vitamin $B_{12}$ (mg/kg) | 0.05 | 0.09 | 0.01[2] | 0.02 | 0.02-0.035 |
| Calcium (%) | 0.76 | 2.1 | 0.97 | 1.0 | 0.5-1.0 |
| Phosphorus (%) | 0.52 | 1.4 | 0.78 | 0.84 | 0.5-0.8 |
| Potassium (%) | 0.45 | 0.78 | 0.71 | 0.71 | 0.4-0.6 |
| Sodium (%) | 0.28 | 0.28 | 0.32 | 0.38 | 0.05-0.4 |
| Magnesium (%) | 0.22 | 0.15 | 0.07 | 0.07 | 0.03-0.08 |
| Iron (mg/kg) | 59.4 | 130 | 191 | 35.8 | 80-114 |
| Zinc (mg/kg) | 129 | 109 | 14.1[2] | 15.3[2] | 50-94 |
| Copper (mg/kg) | 9.9 | 16.8 | 1.62[2] | 1.6[2] | 5.0-8.8 |
| Iodine (mg/kg) | 0.45 | 0.69 | 0.04[2] | [2] | 0.35-2.2 |
| Selenium (mg/kg) | 0.47 | 0.17 | 0.32 | 0.09[2] | 0.1-0.4 |

| Nutrient | Institution F Ferret | Instution H Ferret | Institution I Ferret | | More Carnivorous |
|---|---|---|---|---|---|
| Protein (%) | 33.2 | 35.0 | 43.3 | | 19.7-32.5 |
| Fat (%) | 21.5 | 10.0 | 25.5 | | 9.0-30 |
| Vitamin A (IU/g) | 40.3 | 6.6 | 27.8 | | 2.44-10 |
| Vitamin D (IU/g) | 2.3 | 0.59 | 4.1 | | 0.25-1.0 |
| Vitamin E (mg/kg) | 116 | [2] | 277 | | 27-120 |
| Thiamin (mg/kg) | 30.1 | [2] | 71.1 | | 1.0-5.6 |
| Riboflavin (mg/kg) | 14.9 | [2] | 22.2 | | 1.6-4.25 |
| Pantothenic acid (mg/kg) | 43.2 | [2] | 28.9 | | 5.0-8.0 |
| Niacin (mg/kg) | 154 | [2] | 122 | | 9.6-60 |
| Pyridoxine (mg/kg) | 22.6 | 5.9 | 20 | | 1.6-4.0 |
| Folacin (mg/kg) | 2.9 | [2] | 4.7 | | 0.2-1.3 |
| Biotin (mg/kg) | 0.75 | [2] | 0.53 | | 0.07-0.12 |
| Vitamin $B_{12}$ (mg/kg) | 0.26 | 0.10 | 0.1 | | 0.02-0.035 |
| Calcium (%) | 1.0 | 1.0 | 1.5 | | 0.5-1.0 |
| Phosphorus (%) | 0.93 | 0.73 | 1.4 | | 0.5-0.8 |
| Potassium (%) | 0.86 | 0.67 | 0.62 | | 0.4-0.6 |
| Sodium (%) | 0.30 | 0.40 | 0.44 | | 0.05-0.4 |
| Magnesium (%) | 0.09 | 0.06 | 0.13 | | 0.03-0.08 |
| Iron (mg/kg) | 278 | 169 | 411 | | 80-114 |
| Zinc (mg/kg) | 208 | 200 | 257 | | 50-94 |
| Copper (mg/kg) | 28 | [2] | 25 | | 5.0-8.8 |
| Iodine (mg/kg) | 2.3 | [2] | 2.2 | | 0.35-2.2 |
| Selenium (mg/kg) | 0.56 | 0.67 | 0.62 | | 0.1-0.4 |

| Nutrient | Institution J Skunk | Institution K Skunk | Institution A Skunk | Institution B Skunk | More Omnivorous |
|---|---|---|---|---|---|
| Protein (%) | 25.3 | 19.9 | 23.0 | 22.8 | 17.5-26.0 |
| Fat (%) | 11.0 | 6.9 | 7.4 | 8.8 | 5-8.5 |
| Vitamin A (IU/g) | 6.2 | 42.5 | 131 | 85.6 | 0.5-5.9 |
| Vitamin D (IU/g) | 1.5 | 1.4 | [2] | [2] | 0.5-0.55 |
| Vitamin E (mg/kg) | 51.2 | 81.4 | 10.2[2] | 489 | 27-50 |
| Thiamin (mg/kg) | 1.0 | 14.9 | 3.5 | 0.34[2] | 1.0-2.25 |
| Riboflavin (mg/kg) | 2.1 | 11.2 | 3.6 | 0.21[2] | 1.6-10.5 |
| Pantothenic acid (mg/kg) | 1.7[2] | 27.6 | 7.4 | 0.75[2] | 7.4-15.0 |
| Niacin (mg/kg) | 1.6[2] | 77.1 | 33.4 | 3.0[2] | 11.4-20.0 |
| Pyridoxine (mg/kg) | 1.2 | 12.4 | 3.2 | 0.57[2] | 1.0-1.8 |

| | | | | | |
|---|---|---|---|---|---|
| Folacin (mg/kg) | 0.2 | 1.6 | 0.85 | 0.05[2] | 0.18-0.5 |
| Biotin (mg/kg) | 0.01[2] | 0.37 | [2] | [2] | 0.1-0.12 |
| Vitamin $B_{12}$ (mg/kg) | 0.02 | 0.18 | [2] | [2] | 0.022-0.035 |
| Calcium (%) | 1.3 | 0.66 | 0.39 | 0.64 | 0.5-1.2 |
| Phosphorus (%) | 1.0 | 0.56 | 0.47 | 0.55 | 0.5-1.0 |
| Potassium (%) | 0.6 | 0.92 | 0.94 | 0.81 | 0.4-0.6 |
| Sodium (%) | 0.3 | 0.19 | 0.38 | 0.22 | 0.04-0.3 |
| Magnesium (%) | 0.1 | 0.08 | 0.12 | 0.11 | 0.04-0.06 |
| Iron (mg/kg) | 65.6 | 194 | 26.3 | 1.9[2] | 30-90 |
| Zinc (mg/kg) | 94.9 | 171 | 16.3 | 0.71[2] | 50-120 |
| Copper (mg/kg) | 6.0 | 13.2 | 2.8 | 0.25[2] | 6.0-12.4 |
| Iodine (mg/kg) | 1.1 | 2.0 | [2] | [2] | 0.9-1.54 |
| Selenium (mg/kg) | 0.08[2] | 0.26 | 0.06[2] | [2] | 0.1-0.35 |

| **Nutrient** | Institution L Tayra | Institution K Tayra | | | More Omnivorous |
|---|---|---|---|---|---|
| Protein (%) | 39.9 | 27.3 | | | 17.5-26.0 |
| Fat (%) | 21.2 | 17.7 | | | 5-8.5 |
| Vitamin A (IU/g) | 70.3 | 103 | | | 0.5-5.9 |
| Vitamin D (IU/g) | 2.9 | 1.7 | | | 0.5-0.55 |
| Vitamin E (mg/kg) | 174 | 96.2 | | | 27-50 |
| Thiamin (mg/kg) | 44.2 | 14.4 | | | 1.0-2.25 |
| Riboflavin (mg/kg) | 14.7 | 11.6 | | | 1.6-10.5 |
| Pantothenic acid (mg/kg) | 21.1 | 28.2 | | | 7.4-15.0 |
| Niacin (mg/kg) | 78.6 | 92.7 | | | 11.4-20.0 |
| Pyridoxine (mg/kg) | 14.6 | 7.9 | | | 1.0-1.8 |
| Folacin (mg/kg) | 3.1 | 1.9 | | | 0.18-0.5 |
| Biotin (mg/kg) | 0.33 | 0.37 | | | 0.1-0.12 |
| Vitamin $B_{12}$ (mg/kg) | 0.06 | 0.05 | | | 0.022-0.035 |
| Calcium (%) | 1.3 | 1.4 | | | 0.5-1.2 |
| Phosphorus (%) | 1.1 | 0.97 | | | 0.5-1.0 |
| Potassium (%) | 0.72 | 0.86 | | | 0.4-0.6 |
| Sodium (%) | 0.33 | 0.26 | | | 0.04-0.3 |
| Magnesium (%) | 0.11 | 0.12 | | | 0.04-0.06 |
| Iron (mg/kg) | 340 | 301 | | | 30-90 |
| Zinc (mg/kg) | 182 | 146 | | | 50-120 |
| Copper (mg/kg) | 18.3 | 12.1 | | | 6.0-12.4 |
| Iodine (mg/kg) | 1.3 | 1.4 | | | 0.9-1.54 |
| Selenium (mg/kg) | 0.41 | 0.21 | | | 0.1-0.35 |

[1]Target nutrient levels listed in Table 9.
[2] Missing values in database so nutrients most likely meet targets.

**Provision of Diet:** For many of the mustelids, food containers may not be desirable (e.g., wolverines) because of the animals' tendency to chew on any items they can lift. If animals are fed on floor surfaces, these should be thoroughly cleaned and disinfected daily. If bowls or metal trays are used, they should be placed at an appropriate height for each species and secured so the animal cannot remove or damage the bowl/tray, or themselves.

Food should be offered in containers that are cleaned and sanitized after each use. Meat, rodents, fish, chicken, or similar products can be hidden in the exhibit, particularly for solitary species. Feeding techniques of this type used for pairs or groups should be monitored to ensure all individuals are receiving their share.

Ox tails, rib bones, or knuckle bones should be provided on a regular basis to maintain oral hygiene and muscle tone.

Feeding schedules: As a group, mustelids are mostly diurnal or nocturnal. While it is not possible to mimic the same diet (or environment) for *ex situ* populations of animals as they would consume if they were free-ranging, it is recommended that the diet is offered during the period of the day when the animals would typically be expected to forage actively. This will not only discourage pest species, but will encourage typical foraging behavior. All species should be fed to coincide with their activity patterns. Animals that are not habitually active in the morning should be fed later in the day (to coincide with their "evening", in the case of nocturnal animals housed indoors on reverse-light cycles).

Due to a high metabolic rate and rapid digesta passage rate, it is recommended that mustelids be fed at least twice a day, with more frequent feedings for the more active members of the family (such as weasels, stoats, fisher, mink) (Partridge & Jordan 1995). Unless dictated by age, condition, veterinary treatment, hibernation, etc., some species may require more frequent feedings (e.g., weasels), or respond to more frequent feedings with an increase in overall activity (J. Reed-Smith, personal experience; Fernandez-Moran 2003). Similarly, activity levels will influence nutritional requirements for all of these species and should be considered during diet formulation.

- Skunks: Feeding skunks small amounts of food throughout the day has proven successful at reducing the frequency of regurgitation in these species (D. Smith-Weber, personal communication).
- Weasels: Weasels should be fed 3-4 times a day. At least 2-3 of these feedings should be provided in a novel fashion, varying the feeding times and delivery methods.

However often animals are fed, food remnants should be removed from each previous feeding to prevent spoilage. However, species such as wolverines may benefit from the periodic provision of whole carcasses and/or meat chunks that can be cached for later consumption (Blomqvist & Rudbäck 2001; J. Reed-Smith, personal experience). Food caching by wolverines should be allowed, but monitored for spoilage, particularly in warmer climates and during temperate summers. Varying of feeding times is strongly recommended to prevent the development of "pre-feeding" stereotypical pacing.

Social feeding: Group dynamics often play a role in whether animals are able to consume a nutritionally complete diet. Feeding should be observed to ensure the subordinate animals receive the correct proportions of ingredients. Increasing the number of feeding times per day, placing the food in several locations, distracting some of the animals to allow others adequate access, or separating animals when possible to ensure adequate nutritionally complete feed consumption, may all be necessary for animals housed in a social group.

**Species-appropriate Feeding and Foraging:** All mustelid species should be fed part of their diet as a scattered, enrichment feed. If possible, whole carcass foods of some type should be offered several times a week. Live fish, insects, and hidden, favored food items also promote scavenging.

Wolverine: The scavenger wolverine has evolved as an opportunistic hunter, feeding on whatever is available when preferred sources become scarce. This variety includes plant material and berries in summer, rodents, scavenging carcasses, and meat caching for later consumption. Studies in Norway indicate that there is a correlation between peaks in rodent cycles and reproductive success in this species (Blomqvist 2001).

The provision of whole carcass foods including such things as rabbits, fish, rats, chicks, mice, amphibians, large carcass pieces with bones, etc., make good additions to diets of *ex situ* populations of mustelids. These items promote good dental health and species-appropriate martelism (caching), digging, foraging, and hunting behaviors (Blomqvist & Rudbäck 2001). The feeding of large carcasses or pieces of meat to wolverines that they can cache and feed on for several days may contribute to increased breeding success (Grove 2001). Again, if food caching is allowed, food pieces should be closely monitored for spoilage.

American marten and fisher: American marten and fishers consume a percentage of vegetation as part of their wild diet; part of which may be as a by-product of the prey species they consume, but intentional consumption of vegetable matter (e.g., berries) also occurs (Martin 1996). While vegetation does appear to be important for both of these species, on a seasonal basis, it is believed to be of secondary importance to meat in their diet (Martin 1996). One study reported the fisher eating false truffles (Hypogeous fungi), which has only been recognized in the last 15 years as an important food item to many forest vertebrates (Martin 1996). Wild fishers are known to consume apples in New England from December to March, and habitat studies have shown a disproportionate use of old orchards during this period (J. Ogden, personal communication). In these studies, food habit analysis identified apple as the most abundant item in scat from December to March (Krohn & Gilbert 1989).

A study of wild marten conducted by Bull (2002) analyzed the frequency of occurrence of prey items found in 1014 scat samples associated with 31 radio collared American martens in northeastern Oregon. The scat samples included: "…62.7% vole-sized prey, 28.2% squirrel-sized prey, 22.4% insects, 19.5% birds, 13.3% plant material, and 2.4% lagomorphs". See Buskirk & MacDonald (1984), Lucherini & Crema

(1993), Clevenger (1993), Putman (2000), and Cumberland et al. (2001) for additional information on marten, pine marten, and stone marten diet in the wild.

In the winter, American martens and European pine martens are known to forage extensively under the snow for rodents (Powell 1993). This feeding behavior can be catered to in zoos by hiding small whole prey under snow or other suitable substrates.

Weasel: Several researchers have shown that weasels forage on the ground, in low trees, shrubs, and under the snow (Powell 1993); all of these locations should be used for scattered or hidden feeds.

African striped weasel: This species should be fed several times (3-4) a day (feline diet and rodents). At least two of these rodent feedings should be enrichment feedings. Diet can be offered in different locations, scattered, or in feeding devices requiring the animal to work to access the food. Some of the feeders that have been used successfully include: PVC or cardboard tubes, boxes, suet feeders, puzzle balls, exercise balls, wire mesh feeders, hanging grass huts, toys with holes for food, hanging from plastic chain, carved pumpkins, boomer balls, triangle feeder with cut-outs, bird toys with large holes, phone books, cricket rock with two halves, and logs.

## 5.3 Nutritional Evaluations

An animal's weight should be monitored regularly, and the diet adjusted to maintain the individual at its optimum overall or seasonal weight. An individual's size should be taken into consideration when formulating a diet instead of using generic male/female diets. Some individuals have a tendency toward obesity, and season and activity patterns can affect consumption and subsequent body condition (Verts 1967; Fernandez-Moran 2003). For example, some mustelids undergo a physiological response to decreasing temperatures – storing body fat in fall and winter, and subsequently reducing intake during the cold winter months (Kruuk 1989; Hindmarsh 1995; Martin 1996). For these reasons, "goal weights" for individuals should be established (in general and on a seasonal basis), and body weight checked frequently, so that diet adjustments can be made in a timely fashion to avoid over or under-condition.

Increased or decreased requirements for illness, thermoregulation, or activity can be met by offering diets *ad libitum*, and monitoring body weight and condition over time. In general, diets should be offered so that a small amount of food is remaining at the end of the feeding period. However, body weight should be managed on an individual basis, as some species and individuals tend to become obese if given the chance.

The health status of an individual should be considered when formulating a diet. Animals with chronic conditions should be monitored to ensure that they are consuming sufficient calories and a well-balanced diet. Conditions caused by nutritional deficiencies should be addressed promptly.

in). The den is part of the building, so it's made of cinder block and concrete. For more information on this nest box design contact the AZA SCTAG Chair (Photo: Cindy Colling)


Den


Nest box

## 7.5 Assisted Rearing

Although mothers may successfully give birth, there are times when they are not able to properly care for their offspring, both in the wild and in *ex situ* populations. Fortunately, animal care staffs in AZA-accredited institutions are able to assist with the rearing of these offspring if necessary. If young are removed for hand-rearing, they typically should not be reintroduced to the mother. However, if this situation arises, the AZA SCTAG Chair and other institutions housing the species should be consulted for current practices and any advancement in assisted rearing practices.

**Hand-Rearing:** Hand-rearing may be necessary for a variety of reasons: rejection by the parents, ill health of the mother, or weakness of the offspring (typically known as kit in most mustelids, but badger young may be called cubs). Careful consideration should be given as hand-rearing requires a great deal of time and commitment (Muir 2003). Before the decision to hand-rear is made, the potential for undesirable behavioral problems in a hand-reared adult should be carefully weighed (e.g., aggression towards humans, inappropriate species-specific behavior, etc.), and plans made to minimize deleterious effects on the development of natural behaviors as far as possible. This may require extensive time commitment on the part of staff, plans for fostering, relocation of the young, exposure to species-specific sounds, etc.

Once the decision has been made and the young have been abandoned by the mother, or are consistently getting weaker/losing weight, it is best to remove the kits as soon as possible. See Table 16 for a recommended 'Neonatal Examination and Monitoring Protocol' (Read & Meier 1996).

If young have been abandoned by their mother, it is best to remove them to prevent infanticide. If the offspring are being cared for but receiving no milk, they will be restless and possibly call continuously. Conversely, they may be hypothermic and scattered around the enclosure. Another indicator of trouble would be the female moving around the exhibit continuously while carrying the young; this could mean she is not comfortable with the denning provided, or there is something wrong with her or the young (Muir 2003).

If it is necessary to remove offspring because of an exceptionally large litter, it is best to remove two of the largest kits. The temptation is often to take the smallest, but they stand the best chance if raised by their mother. Hand-rearing of singletons is more likely to lead to severe imprinting than if they have a conspecific to interact with (Muir 2003).

Physical care: Incubators are the best source of warmth; heat lamps are too intense and can be dehydrating; hot water bottles can be used when necessary and hypothermic neonates can be warmed slowly by placing them next to your body (Muir 2003).

Small kits should be kept at a temperature between 26.5-29 ºC (80-85 ºF); young animals die very quickly if they are kept at too high a temperature (Muir 2003). Wallach & Boever (1983) give 29.4 °C (85 °F) and a minimum 50% humidity as the desired incubator setting for mustelids. Meier (1986) suggests 29.4-32 °C (85-90 °F) and 50-60% humidity. The temperature should be gradually reduced to room temperature, 21.2-23.9 °C (70-75 °F), over the course of about three weeks (unless the neonate becomes ill). If the ambient temperature is too high, it may cause hair loss. Most neonates will feel more secure if wrapped in layers of towels; this also aids in keeping them warm (Muir 2003).

Feeding: Young mammals require a specific number of kcal/day for optimum development and growth. If the formula being offered is nutritionally dense, fewer feedings will be required than with formulas that are more dilute or low in fat or protein. Following is a method for calculating the volume of food to be offered

daily, the volume that should be offered at each feeding, and the number of feedings per day (adapted from Grant 2004).

The Basal Metabolic Rate (BMR) or Basal Energy Requirement (BER) is the amount of energy (kcal) an animal needs for basic metabolic function at rest in a thermoneutral zone. In other words, the amount of calories it needs to stay alive without having to use energy to maintain normal body temperatures. The formula to determine the BER/BMR is: 70 x body wt (in kg.)$^{0.75}$ (Kleiber 1947). For a 30g kit (e.g., skunk), the BER would be: 70 x 0.03$^{0.75}$ = 5.0 kcal/day. For a 90g kit (e.g., wolverine), the BER would be: 70 x 0.09$^{0.75}$ = 11.5 kcal/day. For this formula, 0.75 is an exponent that is multiplied by the body weight to put mammals of different sizes on the same playing field when assessing metabolism. As body weight increases, metabolism decreases, so a larger animal will not have the same caloric requirement as a much smaller animal (e.g., mice consume a much higher percentage of their body weight than an elephant does).

Table 22 below provides some pre-calculated MER values. In order to complete the calculations, you will need a scientific calculator that does exponents other than squares. Follow steps 1-3 below to calculate the BER. Add step 4 if you want to calculate the Maintenance Energy Requirement.

1. Key in the body weight (in kg) into the calculator
2. Press the exponent key (on Texas Instrument calculators the button is marked by the symbol $x^y$ representing x with the exponent y) and type in 0.75
3. Press the equals sign, and then multiply that by 70 to get the BER.
4. To calculate the MER, multiply this value by the MER factor (i.e., 2, 3 or 4) to get the kcal required for that particular animal.

Once the BER is established, the Maintenance Energy Requirement (MER) can be calculated. This measurement determines the amount of calories the animal needs to function in a normal capacity at its life stage. For adults in a maintenance life stage, the BER is multiplied by 2. For kits that have a higher metabolism and are developing and growing, the BER is multiplied by 3 or 4 (Evans 1987), depending on the species and other factors. A MER factor of 3 is appropriate for large mustelids (e.g., wolverine) that grow at a slower rate than the smaller species, whereas a factor of 4 may be more appropriate for small mustelids such as mink, black-footed ferrets, and small weasels.

The stomach capacity for most placental mammals is 5-7% of the total body weight (Meehan 1994). Convert the body weight into grams to find the stomach volume in ml (cc). To calculate the stomach capacity in ounces, convert body weight into grams (30 g ~ 1 oz). It is important that units are the same for body weight and stomach volume. The stomach capacity is the amount of formula a kit can comfortably consume at one feeding. Offering much more than this value may lead to overfilling, stomach distension, and bloat. It also prevents complete emptying of the stomach before the next feeding, and promotes the overgrowth of potentially pathogenic bacteria, diarrhea, and enteritis (Evans 1987). The following calculations will determine the total volume and kcal to feed/day, as well as the amount of formula for each feeding and the total number of feedings daily.

- Find Maintenance Energy Requirement (MER): 70 x body wt (kg)$^{0.75}$ x 3 or 4.
- Determine stomach capacity (amount that can be fed at each meal): Body weight (in grams or ounces) x 0.05.
- Divide MER (number of calories required per day) by the number of kcal/ml in the formula to determine the volume to be consumed per day. This value can be converted into ounces, by dividing it by 30.
- Divide ml of formula per day by volume to be consumed at each meal (stomach capacity). This gives the number of meals to be offered per day.
- Divide 24 hours by the number of feedings/day to find the time interval between feedings.

Table 22: Example neonate feeding calculations for hand-reared mustelids

| Example/Species | Calculations* |
|---|---|
| Example 1:<br>Newborn hog-nosed skunk.<br>Approx. birth wt = 30g | 1. 70 x 0.03kg $^{0.75}$ x 3 = 20.2kcal/day<br>2. 30g x 0.05 (stomach capacity of 5% body wt) = 1.5g (ml) can be consumed/feeding<br>3. With a formula that contains 1.53kcal/ml:<br>20.2kcal/day = 13.2ml/day<br>1.53kcal/ml<br>4. 13.2ml/day = 8.8 feedings/day (round up to 9)<br>1.5ml/feeding<br>5. 24 hours/ 9 feedings = 2.5-3 hours between feedings during the first week. |
| Example 2:<br>Newborn wolverine. Approx. birth wt = 84-94g | 1. 70 x 0.09kg.75 x 3 = 34.5kcal/day<br>2. 90g x 0.05 [5% body wt] = 4.5g (ml)<br>3. With a formula that contains 1.02kcal/ml:<br>34.5kcal/day = 33.8ml/day<br>1.02kcal/ml<br>4. 33.8ml/day = 7.5 feedings (round up to 8)<br>4.5ml/feeding<br>5. 24hours / 8 feedings = feed every 3 hours |

* New calculations should be performed every few days so formula volume can be adjusted to accommodate growth. The general target average daily gain for kits is 5% increase of body wt/day while on formula feeding, and 5-10% body wt increase/day on weaning diet (Grant 2005a,b,c).

Initially, the animal should receive only an electrolyte solution for the first 2-3 feedings, depending on how compromised it is. This is to rehydrate the animal and clear the stomach of the maternal milk. Then, the artificial formula can be started at a diluted concentration, generally at a 1:4 ratio (mixed formula: water) for another 2-3 feedings. It generally takes 48-72 hours to get the animal on full-strength formula by gradually offering higher concentrations. Depending on the species, 3-4 feedings of each concentration level (1:3, 1:2, 1:1, full-strength) are recommended to allow for adaptation and to minimize the onset of digestive problems, particularly diarrhea. During the initial phase, weight loss is to be expected, but the animal should quickly begin to maintain weight and then start gaining as the formula concentration increases. It is important that the kits not be given full strength formula too soon (in less than 48 hours after pulling for hand-rearing), because the likelihood of diarrhea occurring is extremely high. Diarrhea is of particular concern with neonates less than one week of age, because they have very little or no immunity to infections.

The stomach capacity of most eutherian mammals is 5% body weight (bw). This is the volume of formula that should be offered at each feeding (Grant 2004). The total volume offered per day will depend on how nutrient dense the formula is. The optimal amount would be the number of kcal calculated from the kit's body weight (see Table 23).

Table 23: Chart used for determining kcal/day and stomach capacity for various body weights (Grant 2004)

| Weight (grams) | MER (kcal/day) [70 x bw (kg)$^{0.75}$ x 3] | MER (kcal/day) [70 x bw (kg)$^{0.75}$ x 4] | Stomach capacity (ml/feeding) |
|---|---|---|---|
| 5.0 | 3.95 | 5.25 | 0.25 |
| 6.0 | 4.5 | 6.0 | 0.30 |
| 7.0 | 5.1 | 6.8 | 0.35 |
| 8.0 | 5.6 | 7.5 | 0.40 |
| 9.0 | 6.1 | 8.2 | 0.45 |
| 10.0 | 6.6 | 8.9 | 0.50 |
| 11.0 | 7.1 | 9.5 | 0.55 |
| 12.0 | 7.6 | 10.2 | 0.60 |
| 13.0 | 8.1 | 10.8 | 0.65 |
| 14.0 | 8.5 | 11.4 | 0.70 |
| 15.0 | 9.0 | 12.0 | 0.75 |
| 16.0 | 9.4 | 12.6 | 0.80 |
| 17.0 | 9.9 | 13.2 | 0.85 |
| 18.0 | 10.3 | 13.8 | 0.90 |
| 19.0 | 10.7 | 14.3 | 0.95 |
| 20.0 | 11.2 | 14.9 | 1.0 |
| 25.0 | 13.2 | 17.6 | 1.25 |
| 30.0 | 15.1 | 20.2 | 1.50 |
| 35.0 | 17.0 | 22.7 | 1.75 |
| 40.0 | 18.8 | 25.0 | 2.0 |
| 45.0 | 20.5 | 27.4 | 2.25 |
| 50.0 | 22.2 | 29.6 | 2.5 |
| 55.0 | 23.9 | 31.8 | 2.75 |
| 60.0 | 25.5 | 33.9 | 3.0 |
| 65.0 | 27.0 | 36.0 | 3.25 |
| 70.0 | 28.6 | 38.1 | 3.5 |
| 75.0 | 30.1 | 40.1 | 3.75 |
| 80.0 | 31.6 | 42.1 | 4.0 |
| 85.0 | 33.1 | 44.0 | 4.25 |
| 90.0 | 34.5 | 46.0 | 4.5 |
| 95.0 | 35.9 | 47.9 | 4.75 |
| 100 | 37.3 | 49.8 | 5.0 |
| 125 | 44.1 | 58.9 | 6.25 |
| 150 | 50.6 | 67.5 | 7.5 |
| 175 | 56.8 | 75.8 | 8.75 |
| 200 | 62.8 | 83.7 | 10.0 |
| 250 | 74.2 | --- | 12.5 |
| 300 | 85.1 | --- | 15.0 |
| 350 | 95.6 | --- | 17.5 |
| 400 | 105.6 | --- | 20.0 |

As a general rule, animals should not have an overnight break between feedings longer than twice the time period between daytime feedings (equivalent to missing one feeding). For example, if you are feeding every three hours during the day, they can go six hours at night without food. When they are eating every four hours, they can go eight hours at night. It is not advisable to go more than eight hours between feedings with species that typically nurse throughout the day when mother-raised. Intervals between feeding also will depend on how healthy or strong the kits are. Very weak neonates will probably need feedings every few hours even through the night; typically, this is necessary for only a few days to a week.

Feed only if the kit is hungry and suckling vigorously. Weak kits may be hypothermic, dehydrated, and/or hypoglycemic. Do not offer anything by mouth until the body temperature is within the normal range for its age. Offer oral electrolytes if it will suckle, or give subcutaneously if it is weak or dehydrated. Offer 2.5% or 5% dextrose to raise glucose level, if necessary. Neonates will not die from being slightly underfed, but overfeeding may result in gastrointestinal disease that is potentially fatal. Young animals will be hungry at some feedings and less at others, but this is quite normal (Muir 2003).

It is important to keep in mind that neonates are obligate nose breathers, and incapable of breathing through their mouths and nursing at the same time. For this reason, respiratory infections can be life threatening, because they may interfere with breathing and make nursing difficult or impossible (Meier 1985). Aspirated formula is frequently a contributing factor to neonatal respiratory infections; to avoid this, be sure to select the appropriate nipple. The nipple's hole needs to suit the neonate's sucking reflex. Also, if a nipple is too stiff, the kit may tire and refuse to nurse.

The neonate should be held in the correct nursing position; ventrally or sternally recumbent (tummy down, not on its back), with the head up. Place the hand holding the bottle in such a way that it provides a surface for the kit to push against with its front feet. If milk comes through their nose, the nipple hole may be too large or the kit may be trying to eat too quickly.

If an animal aspirates fluids the recommended protocol is to hold the kit with head and chest lower than the hind end. A rubber bulb syringe should be used to suck out as much fluid from the nostrils and the back of the throat as possible. If aspiration is suspected, or if fluid is heard in the lungs, contact the veterinarian immediately; do not administer drugs without the veterinarian's involvement. Monitor body temperature closely for the occurrence of a fever and a decline in the animal's appetite and general attitude. Depending on the condition and age of the animal, diagnostic procedures may include radiographs, CBC, or chemistry. It is possible to start a course of antibiotics while results from the bloodwork are pending, and the attending veterinarian can prescribe an appropriate antibiotic course.

Digestive upset is a common issue with hand-reared neonates and may be associated with several factors (Meier 1985), including: a) inappropriate milk formula, b) feeding frequency, c) overfilling the stomach, and d) rapid changes in the diet. When digestive upset occurs, characterized by diarrhea, bloating, inappetance, and/or extreme fussiness, it is recommended that one factor is analyzed and/or changed at a time.

Hand-rearing formulas: It is important that the artificial milk formula matches the maternal milk in protein, fat, and carbohydrate composition as closely as possible.

Different formulas and combinations have been used for mustelids. Some experienced hand-rearers recommend using formulas based on goat's milk, because small carnivores cannot absorb the fat globules in cow's milk (Muir 2003). However, the composition of goat's milk varies significantly from that of mustelids. Goat's milk contains 27.7% protein, 31.5% fat, and 34.6% carbohydrates (DM basis). Of the documented mustelid maternal milks, the range for protein is 26-40%, for fat it is 31.2-45.1%, and for carbohydrates it is 7.8-21% (DM basis) (Jenness & Sloan 1970). Goat's milk is up to 31% deficient in protein, and exceeds the carbohydrate content by 1.6-4 times that of mustelids. This excessive carbohydrate level has a great potential to cause gastrointestinal disease if goat's milk is fed alone. Modifications to goat's/cow's milk, by adding egg yolk and gelatin powder to increase protein and fat, has been used with *ex situ* populations of felids in South Africa (Hedberg 2000) and may be adequate as an emergency formula. However, it should be noted that this diet would not be balanced in vitamins and minerals for mustelids. More typically, feline or canine milk replacers are used for hand-rearing mustelids (Muir 2003). It is preferable to use nutritionally complete formulas such as KMR® and Multi-Milk® (or Milk Matrix™ 42/25 + 30/55) should be combined/balanced to match the maternal milk as closely as possible. See Table 25 for maternal milk compositions and recommended hand-rearing formulas.

Table 24: Maternal milk composition and hand-rearing formulas for mustelids (values given are on "as fed" basis. DM basis provided in parentheses)

| Species/formula*** | Solid% | Fat % | Protein% | Carbs % | Kcal/ml |
|---|---|---|---|---|---|
| **Badger** (maternal milk)[1] | 18.6 | 6.3 (33.9) | 7.2 (38.7) | 3.5 (18.8) | 1.0 |
| **Badger** (hand-rearing formula)[2]<br>Esbilac (33/40) - 1 part<br>KMR (42/25) - 1 part<br>Water - 3½ parts | 18.4 | 6.5 (35.3) | 7.3 (39.7) | 3.5 (19.0) | 1.02 |
| **Hog-nosed skunk** (maternal milk)[1] | 34.6 | 10.8 (31.2) | 10.8 (31.2) | 2.7 (7.8) | 1.51 |
| **Hog-nosed skunk** (hand-rearing formula #1)[2]<br>KMR (42/25) - 1 part<br>Multi-milk (30/55) - 1¼ parts<br>Water - 2¼ parts | 28.2 | 11.4(40.4) | 10.1(35.8) | 2.5 (8.9) | 1.53 |
| **Hog-nosed skunk** (hand-rearing formula #2)[2]<br>Esbilac (33/40) - 1 part<br>Multi-milk (30/55) - 1/3 part<br>Water - 1½ parts | 24.8 | 11.7(47.2) | 8.4(33.9) | 2.9 (11.7) | 1.51 |
| **Mink** (maternal milk)[1] | 21.7 | 7.2 (33.0) | 5.6 (26.0) | 4.6 (21.0) | 1.05 |
| **Mink** (hand-rearing formula #1)[2]<br>Multi-milk (33/40) – 1 part<br>Multi-milk (25/13) – 1/3 parts<br>Water – 2 parts | 21.7 | 6.6 (30.4) | 6.9 (31.8) | 3.3(15.2) | 1.02 |
| **Mink** (hand-rearing formula #2)[2]<br>Esbilac (33/40) – 1 part<br>KMR (42/25) – 1 part<br>Water – 3 parts | 20.8 | 7.3 (35.1) | 8.3 (39.9) | 4.0 (19.2) | 1.15 |
| **Striped skunk** (maternal milk)[1] | 30.6 | 13.8 (45.1) | 9.9 (32.4) | 3.0 (9.8) | 1.76 |
| **Striped skunk** (hand-rearing formula #1)[2]<br>Multi-milk (30/55) - 1 part<br>Non-fat dry milk - 1/3 part<br>Water - 1 1/3 parts | 28.2 | 12.3 (43.6) | 8.7 (30.9) | 3.1 (11.0) | 1.58 |
| **Striped skunk** (hand-rearing formula #2)[2]<br>KMR (42/25) - ½ part<br>Multi-milk (30/55) - 1 part<br>Water - 1½ parts | 27.0 | 12.4 (45.9) | 9.7 (35.9) | 2.3 (8.5) | 1.59 |
| **Striped skunk** (hand-rearing formula #3)[2]<br>Esbilac (33/40) - 1 part<br>Heavy whipping cream - ¼ part<br>Water - 1 ¼ parts | 25.7 | 13.8 | 7.3 | 3.5 | 1.68 |
| **Wolverine** (maternal milk)** | n/a | n/a | n/a | n/a | n/a |
| **Wolverine** (**hand-rearing formula)[2]<br>Esbilac (33/40) - 1 part<br>KMR (42/25) - 1 part<br>Water - 3½ parts | 18.4 | 6.5 (35.3) | 7.3 (39.7) | 3.5 (19.0) | 1.02 |

[1] Jenness & Sloan (1970); [2] Marcum (1997)
** Maternal milk composition is not available for wolverines. Hand-rearing formula for badgers is acceptable for wolverines (n/a = not available).
*** Pet Ag® (manufacture KMR®, Esbilac®, Multi-Milk® and the Zoologic Milk Matrix line: 261 Keyes Ave., Hampshire, IL. 60140, 1-800-323-0877/ 1-800-323-6878 www.petag.com).

The amino acid taurine is present in the colostrum and milk of many mammals, and is present at particularly high levels in the milk of obligate carnivores (Robbins 1993). Domestic cat milk contains 287µmol of taurine in 100ml of milk, and the level in dog milk is 181µmol/100ml of milk (Robbins 1993). This compares with 1.0µmol taurine/100ml in cow's milk. Although the taurine content of mustelid milk has not been documented, it is reasonable to expect a concentration comparable to that of cats and dogs. Many species have the ability to synthesize taurine from other sulfur-containing amino acids, such as cysteine and methionine; obligate carnivores do not. Taurine deficiency results in cardiomyopathy and degeneration of the retina, both of which have been documented in *ex situ* populations of felids (Howard et al. 1987; Burton et al. 1988).

Taurine is not included in the Pet-Ag™ formulas Esbilac (33/40)® or Multi-Milk (30/55)®. At this time, KMR (42/25)® is the only commercial formula with added taurine, because it is an essential amino acid in felids. Chicken baby food and clams/clam juice also are reportedly good sources of taurine (Hedberg 2000). While the mustelid requirement for taurine is unknown at this time, it may be beneficial to supplement milk formulas which do not include KMR®, as part of the base, with taurine. The recommended taurine supplementation for felids is 250mg/animal/day (McManamon & Hedberg 1993).

Weaning: By 5-6 weeks of age, solids should be introduced, either finely ground nutritionally complete meat mix with the formula, or something similar depending on the species (however, chicken has tended to cause diarrhea in some small carnivores). If necessary, this can be offered on the handler's fingers to encourage them to eat. Some experienced handlers recommend that formula should be offered in a bowl as long as the animal will take it. This will ensure the young animal is receiving adequate calcium. However, it is important that the animal is eating its adult diet as well (Muir 2003).

- Ferret: If at all possible it is best to leave kits with the dam. Kits can be left with the jill to continue stimulation of milk production while being fed supplemental milk formula. Puppy (Esbilac®) or kitten (KMR®) milk replacers have both been used with the addition of whipping cream to bring the fat content to 20% (roughly 3:1). A 3cc syringe fitted with a cannula works well until the kit is able to suck from a small pet-nursing bottle. Initial feedings should offer about 0.5cc increasing to ~1.0cc by the end of the first week. By the end of three weeks, the kit should be taking about 6-8cc from the bottle; at this point they can be weaned to a bowl. Initially, kits should be fed every two hours around the clock, gradually reducing the number of night feedings over the next couple of weeks. By three weeks, feedings should be every 3-4 hours and softened adult food may be offered (McKimmey 2002).
- Long-tailed weasel: Long-tailed weasels have been raised successfully from about one month of age using powdered Esbilac® at a 1:2 ratio, Esbilac® to water. The kittens should be fed every two hours ± 30 minutes. While a break of four hours between feedings during the night is acceptable, it is preferable to feed around the clock when kittens are younger, because this species has a very high metabolism (D. DeMyer, personal communication). At approximately 34 ± 2 days, chopped pinkies may be offered at every other feeding in addition to formula. The kittens readily consume solids even though their eyes are not open yet. It is important to ensure a nutritionally complete diet, so pinkies should be supplemented with an appropriate carnivore diet early on. Kittens may be weaned by the time their eyes are open at approximately 45 days. The management techniques important to the successful rearing of this species are (D. DeMyer, personal communication): 1) keeping kittens warm and offering them a choice of temperature (heat lamp, heating pad), 2) providing hiding places (cork bark, pvc pieces, etc.), 3) consistent staff (kittens with their eyes closed can react aggressively to strange smells), and 4) frequent feedings.
- Mink: While the mink are not a species recommended for management by the AZA SCTAG, there has been a great deal of work on this species (e.g., Kaar et al. 1998; Jeppesen et al. 2000; Sorensen et al. 2001), which may be helpful for other closely related species as well.
- Wolverine: General development milestones for mother-reared kits include the following (from an AZA-accredited zoo's records – Table 25):

Table 25: Development of mother-reared wolverine kits

| Day | Developmental stage |
|---|---|
| ~15 | Coat beginning to change color (face darkening) |
| 18 | Doubled in size |
| 26 | Eyes beginning to open |
| 33 | Beginning to walk |
| 40 | Moving around den/sometimes sleeping on own |
| ~53 | Climb out of den on own |
| 80 | First solid foods |
| 90 | Eating solids well |

From left to right: Wolverine kits (Institution C) at 1 week, 5-6 weeks, and 3 months of age (Photo credit: L. Monska).

## 7.6 Contraception

Many animals cared for in AZA-accredited institutions breed so successfully that contraception techniques are implemented to ensure that the population remains at a healthy size. In addition to reversible contraception, reproduction can be prevented by separating the sexes or by permanent sterilization. In general, reversible contraception is preferable because it allows natural social groups to be maintained, where appropriate, while managing the genetic health of the population. Permanent sterilization may be considered for individuals that are genetically well-represented, or for whom reproduction would pose health risks. The contraceptive methods most suitable for mustelids are outlined below. More details on products, application, and ordering information can be found on the AZA Wildlife Contraception Center (WCC) webpage: www.stlzoo.org/contraception.

The progestin-based melengestrol acetate (MGA) implant, previously the most widely used contraceptive in zoos, has been associated with uterine and mammary pathology in felids and suspected in other carnivore species (Harrenstien et al. 1996; Munson et al. 2002; Munson 2006). Other progestins (e.g., Depo-Provera®, Ovaban®) are likely to have the same deleterious effects. For carnivores, the AZA Wildlife Contraception Center now recommends GnRH agonists, e.g., Suprelorin® (deslorelin) implants (e.g., Bertschinger et al. 2001) or Lupron Depot® (leuprolide acetate), as safer alternatives. Although it appears safe and effective, dosages and duration of efficacy have not been systematically evaluated for all species. GnRH agonists can be used in either females or males, and side effects are generally those associated with gonadectomy, especially weight gain, which should be managed through diet. Suprelorin® was developed for domestic dogs and has been used successfully in many species of otters, mongoose, and ferrets.

**Gonadotropin releasing hormone (GnRH) agonists:** GnRH agonists (Suprelorin® implants, or Lupron Depot®) achieve contraception by reversibly suppressing the reproductive endocrine system and preventing production of pituitary (FSH and LH) and gonadal hormones (estradiol and progesterone in females and testosterone in males) (Munson et al. 2001). The observed effects are similar to those following either ovariectomy in females or castration in males, but are reversible. GnRH agonists first stimulate the reproductive system, which can result in estrus and ovulation in females or temporary enhancement of testosterone and semen production in males. Then, down-regulation follows the initial stimulation. The stimulatory phase can be prevented in females by daily Ovaban administration for one week before and one week after implant placement (Wright et al. 2001).

GnRH agonists should not be used during pregnancy, since they may cause spontaneous abortion or prevent mammary development necessary for lactation. They may prevent initiation of lactation by inhibiting progesterone secretion, but effects on established lactation are less likely. New data from domestic cats have shown no effect on subsequent reproduction when treatment began before puberty; no research in prepubertal mustelids has been conducted.

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# Appendix G: Description of Nutrients

Adapted from U.S. National Library of Medicine

**Protein:** Protein is the main building blocks of animal structure on a fat-free basis. In addition to being an important constituent of animal cell walls, protein is one of the nutrients responsible for making enzymes, hormones, lipoproteins, and other crucial elements needed for proper bodily functions. Protein also is essential for building and repairing body tissue, as well as protecting the animal from harmful bacteria and viruses. Furthermore, protein aids in the transportation of nutrients throughout the body and facilitates muscle contractions. The requirements for crude protein are effectively requirements for dietary amino acids. The requirements are based on the needs of the animal, the quality of the protein, the source of the protein, and the digestibility of the protein available.

**Fat:** Dietary fat plays an important role in the manufacture of certain hormones. It also plays a crucial role in a wide variety of chemical bodily functions. Also, fat functions as a concentrated energy source, serves as a carrier for fat-soluble vitamins (Vitamins A, D, E, and K), and provides essential fatty acids. The requirements for fat are effectively requirements for dietary fatty acids.

**Vitamin A:** Vitamin A is a fat-soluble vitamin essential for maintaining good vision and healthy mucous membranes. It contributes to the differentiation and growth of skin tissue and bone formation (including teeth), as well as bone remodeling in growing animals, and glycoprotein synthesis. Vitamin A can improve skin and hair/fur conditions, help to increase resistance to certain infections, and improve fertility in both genders. In many cases, a vitamin A requirement is effectively a requirement for carotenoids (precursors to vitamin A).

**Vitamin C (Ascorbic Acid):** Vitamin C is a water-soluble antioxidant, which plays an important role in biochemical oxidation-reduction reactions, as well as in the formation of collagen, an important protein needed for the formation of skin, scar tissue, tendons, ligaments, and blood vessels. Because of this, Vitamin C is crucial to an animal's ability to heal wounds and repair and or maintain cartilage, teeth, and bones. It also may reduce infection by increasing immunity.

**Vitamin D:** Vitamin D is a fat-soluble vitamin necessary for active calcium absorption, calcium metabolism and resorption from bone. Requirements for vitamin D can be totally or partially met by exposure to sunlight or artificial UV light (vitamin D is biosynthesized in the skin of animals or in some plant cells upon exposure to the appropriate wavelength of UV light; 285-315nm).

**Vitamin E:** Vitamin E is a fat-soluble antioxidant that helps to maintain the structure of cellular and subcellular membranes by preventing oxidation of unsaturated fatty acids. It also protects tissues from free radicals, which are substances known to harm cells, tissues, and organs. Vitamin E is essential in the formation of red blood cells and aids the body in Vitamin K utilization.

**Thiamine (B-1):** Thiamine is a water-soluble vitamin, which functions as a necessary coenzyme in carbohydrate metabolism (converting carbohydrates into energy) and is hypothesized to play a role in nerve or neuromuscular impulse transmission. Thiamine also is important in the proper functioning of the heart, muscles, and the nervous system.

**Riboflavin (B-2):** Riboflavin is a water-soluble vitamin. It functions in two coenzymes: Flavin adenine dinucleotide or "FAD" and flavin mononucleotide. Riboflavin is important for growth and the production of red blood cells. It also helps the body to release energy from carbohydrates. Microbial synthesis of riboflavin occurs in the gastrointestinal tract of some animals, but synthesis appears to be dependent on the type of animal and the source of dietary carbohydrate.

**Niacin (Nicotinic Acid):** Similar to Riboflavin, niacin is a water-soluble vitamin which functions in two coenzymes: Nicotinamide adenine dinucleotide or "NAD" and nicotinamide adenine dinucleotide phosphate or "NADP". Niacin plays a crucial role in assisting the normal functioning of the digestive, skin, and nerve systems. Like riboflavin, niacin helps the body to convert energy from food. The niacin requirement of many animals theoretically could be satisfied by synthesis of the vitamin from the amino acid tryptophan. However, removal rate of an intermediate in the pathway to create niacin is often so rapid that virtually none is produced.

**Pyridoxine (B-6):** Pyridoxine also known as B-6 is a water-soluble vitamin, which aids the body in the synthesis of antibodies by the immune system. It also plays a role in the formation of red blood cells and helps to promote healthy nerve functions. Pyridoxine is required to produce the chemical activity necessary for protein digestion.

**Choline:** Choline is an essential nutrient, which contributes to the function of nerve cells. It is a component (helps to form phosphatidylcholine, the primary phospholipid of cell membranes) of the phospholipid lecithin (found in cells throughout the body) and is critical to normal membrane structure and formation. It also functions as a "methyl donor", but this role can be completely replaced by excess amounts of the amino acid methionine in the diet.

**Folacin (Folate, Folic Acid, B-9, Pteroylglutamic Acid):** Folacin, or folate, is a water-soluble vitamin, which assists the body in the formation of red blood cells. It also plays a major role in the formation of genetic material (synthesis of DNA, the hereditary and functioning blueprint of all cells) within all living cells. Folacin functions as a coenzyme, which is important at the cellular and subcellular levels in decarboxylation, oxidation-reduction, transamination, deamination, phosphorylation, and isomerization reactions. Working in conjunction with Vitamin C and B-12, Folacin assists in digestion and protein utilization and synthesis. This vitamin may be used to increase appetite and stimulate healthy digestive acids.

**Vitamin B-12:** Vitamin B-12 is a water-soluble vitamin, which functions as a coenzyme in single carbon and carbohydrate metabolism. In addition to playing a role in metabolism, B-12 assists in the formation of red blood cells and aids in the maintenance of the central nervous system.

**Pantothenic Acid:** Pantothenic acid is a water-soluble vitamin and part of the B vitamin complex. It is needed to break down and use (metabolize) food. Pantothenic acid also is needed for the synthesis of both hormones and cholesterol.

**Calcium:** The mineral calcium (in association with phosphorus) is a major component of the body and is largely associated with skeletal formation. It is important in blood clotting, nerve function, acid-base balance, enzyme activation, muscle contraction, and eggshell, tooth, and bone formation and maintenance. It is one of the most important minerals required for growth, maintenance, and reproduction of vertebrates.

**Phosphorus:** In addition to acting as a major component of the body and being largely associated with skeletal and tooth formation (in conjunction with calcium), phosphorus is involved in almost every aspect of metabolism (energy metabolism, muscle contractions, nerve function, metabolite transport, nucleic acid structure, and carbohydrate, fat, and amino acid metabolism). Phosphorus is needed to produce ATP, which is a molecule the body uses to store energy. Working with the B vitamins, this mineral also assists the kidneys in proper functioning and helps to maintain regularity in heartbeat.

**Magnesium:** Magnesium is a mineral, which serves several important metabolic functions. It plays a role in the production and transport of energy. It also is important for the contraction and relaxation of muscles. Magnesium is involved in the synthesis of protein, and it assists in the functioning of certain enzymes in the body.

**Potassium:** Potassium is a mineral that is involved in both electrical and cellular functions in the body. (In the body it is classified as an electrolyte.) It has various roles in metabolism and body functions. Potassium assists in the regulation of the acid-base balance and water balance in blood and the body tissues. It also assists in protein synthesis from amino acids and in carbohydrate metabolism. Potassium is necessary for the building of muscle and for normal body growth, as well as proper functioning of nerve cells, in the brain and throughout the body.

**Sodium (salt):** Sodium is an element, which the body uses to regulate blood pressure and blood volume. Sodium also is critical for the functioning of muscles and nerves.

**Iron:** Iron is a trace element and is the main component of hemoglobin (oxygen carrier in the blood), myoglobin in muscles (oxygen carrier with a higher affinity for oxygen than hemoglobin), and many proteins and enzymes within the body. It also functions in immune defenses against infection.

**Zinc:** Zinc also is a trace element that is second only to iron in terms of concentration within the body. Zinc plays an important role in the proper functioning of the immune system in the body. It is required for the enzyme activities necessary for cell division, cell growth, and wound healing. It plays a role in the acuity of the senses of smell and taste. Zinc also is involved in the metabolism of carbohydrates. Zinc is essential for synthesis of DNA, RNA, and proteins, and it is a component or cofactor of many enzyme systems.

**Manganese:** Manganese is essential for carbohydrate and lipid metabolism, for synthesis of one of the precursors to cartilage formation, and for proper bone formation. Manganese plays a key role in the growth and maintenance of tissues and cartilage, specifically proper bone development. It particularly aids in development at the ends of bones where new bone formation takes place. This therefore helps to reduce the risk of osteoporosis. Manganese also helps to produce certain hormones, metabolizes fat, and is part of superoxide dismutase (SOD) an antioxidant. Studies on humans have shown that manganese also may lower the frequency of epileptic seizures and enhance immune functioning.

**Copper:** Copper is an essential trace mineral present in all body tissues. Copper, along with iron, helps in the formation of red blood cells. It also helps in keeping the blood vessels, bones, and nervous and immune systems healthy.

**Selenium:** Selenium is an essential trace element. It is an integral part of enzymes, which are critical for the control of the numerous chemical reactions involved in brain and body functions. Selenium has a variety of functions. The main one is its role as an antioxidant in the enzyme selenium-glutathione-peroxidase. This enzyme neutralizes hydrogen peroxide, which is produced by some cell processes and would otherwise damage cell membranes. Selenium also seems to stimulate antibody formation in response to vaccines. It also may provide protection from the toxic effects of heavy metals and other substances. Selenium may assist in the synthesis of protein, in growth and development. In humans, selenium has been shown to improve the production of sperm and sperm motility.

**Iodine:** Iodine is a trace mineral and an essential nutrient. Iodine is essential for the normal metabolism of cells. It is a necessary nutrient for the production of thyroid hormones and normal thyroid function.

# Appendix L: Mustelid Enrichment Ideas – AZA Member Institutions

The following lists provide examples of mustelid enrichment items. All items should be approved by facility management, including the appropriate curator, veterinarian, nutritionist, and horticultural staff.

**Ferret/polecat**

Sensory

- Crickets in escape-proof container
- Snake shed
- Spices and scents
- Urine/trapping lures
- Bath & Body Works lotions & sprays
- Diluted extracts
- Perfume pages from magazines
- Paper, paint, stickers on outside of window
- Sun catcher outside enclosure
- Diluted Eucalyptus oil (5 drops/gal. water)
- Diluted essential oils
- Mirror mobile outside exhibit
- Audio tapes
- Baby mirrors (unbreakable)
- Hooves (monitor)
- Feathers (frozen for 30 days)
- Non-toxic bubbles
- Herbs, spices
- Camel hair/wool (frozen for 30 days)
- Squirrel call
- Hand held or box fan (outside of exhibit)
- Pinwheels outside exhibit
- Disco ball outside exhibit

Foods and feeding

- Cardboard box with
- Food inside
- Buster food cube
- Pinecone
- Egg carton puzzle feeder
- Small bones
- Wax worms in a feeder
- Bones (monitor)
- Crazy ball feeder
- Feed bag with diet (remove liners)
- Hay or leaves
- Boomer ball puzzle feeder
- PVC bug feeder
- Piñatas
- Frozen fruit pops
- Nyla bones/Healthy edibles
- Kong toy with diet
- Carved pumpkin with diet
- Burlap bag with insects
- Live fish in water tub
- Applesauce smears
- Coconut feeder
- Peanut butter smears

Manipulative items/toys

- Balls with/without bells inside
- Kong toy
- Antlers
- Seashells
- Paper materials to shred
- Cardboard boxes/tubes
- Tennis ball
- Small boomer ball
- Pine cones
- Burlap pillows
- Phone books
- Wiggly giggly ball
- Fire hose
- Furry mouse cat toy - supervised
- Small stuffed animals with detachable parts
- Ferret ball

Physical environment

- Exercise inside/outside with supervision
- Straw bedding
- Large cardboard tubes to crawl through
- Exercise ball to crawl through
- 5” PVC pipe to crawl through
- Articles of clothing (sleeves, pant leg)
- Pool with small amount of water (supervised)
- Shredded paper
- Ferret hammock
- Varied substrate, soil
- mulch, etc.
- Snow, sod, sand
- Large hamster ball
- Linen bed sheets
- Frisbee swing suspended with twine

Behavioral/social

- Training programs
- View of decoy animals
- Taken around the zoo to see other animals
- Shredded paper for bedding

**Fisher**

Sensory
- Bison fur
- Scents
- Feathers
- Sheep wool

Foods and feeding
- Tuna-sicles
- HB eggs
- Mice
- Cylinder feeder
- Quail

Manipulative items/toys
- Pumpkins
- Cardboard boxes
- Paper leaf bags
- Rope toys

Physical environment
- Pine trees
- Antlers
- Box of straw
- PVC tubes

**Skunk**

Sensory
- Crickets in escape proof container
- Snake sheds
- Scents
- Urine/trapping lures
- Bath & Body Works lotions & sprays
- Diluted extracts
- Perfume pages from magazines
- Audio tapes
- Mirror (unbreakable)
- Hooves (monitor)
- Feathers (frozen 30 days)
- Squirrel call
- Sun catcher outside enclosure
- Diluted essential oils
- Hand-held or box fan outside of exhibit
- Pinwheels outside exhibit
- Bird calls
- Mirror mobile outside exhibit
- Non-toxic bubbles
- Herbs, spices
- Camel hair/wool (frozen 30 days)

Foods and feeding
- Cardboard box, ball, feeders with diet
- Buster food cube
- Pinecone
- Egg carton puzzle feeder
- Crazy ball feeder
- Feed bag with diet (liner removed)
- Peanut butter smears
- PVC insect feeder
- Piñatas
- Nyla bones/healthy edibles
- Kong toy with diet
- Carved pumpkins with diet
- Burlap bags with insects
- Live fish in tub
- Applesauce smears
- Coconut feeder

Manipulative items/toys
- Kong toy
- Small stuffed animals with detachable parts
- Antlers
- Paper bags, paper to shred
- Tennis balls
- Small boomer ball
- Ferret ball
- Pine cones
- Burlap pillows
- Cardboard boxes/tubes
- Phone books
- Wiggle giggly ball
- Fire hose
- Klinker ball

Physical environment
- Exercised inside/outside with supervision
- Large drain pipe to crawl through
- Pool with small amount of water (supervised)
- Varied substrate – sand, shredded paper, sod, etc.
- Visual barrier
- Hammock

Behavioral/social
- Training programs
- View of decoy animals
- Taken around the zoo to see other animals

**Wolverine**

Sensory

- Bengay ointment in a boomer ball
- Logs from other exhibits
- Urine scents, lures
- Spices and extracts
- Burlap bags with scented straw
- Bison, pronghorn, moose, elephant feces
- Deodorant spray
- Feathers
- Pig ears, cow hooves
- Reindeer antlers
- Pronghorn sheaths
- Hair from other species
- Education animals allowed to use exhibit while wolverines are in holding, then allowed back into exhibit after the animals has been removed

Foods and feeding

- Frozen mice, rats, fish hidden around exhibit
- Liver
- Rats and mice (dead)
- Rabbit (dead)
- Knuckle, shank & rib bones
- Super worms & crickets
- Live crayfish & fish
- Pumpkins, apples, grapes, HB eggs
- Rat/Mouse sickles
- Blood popsicles
- Anchovy (fish) paste
- Tuna fish
- Beef heart
- Clams and krill
- Hot dogs and chunk meat

Manipulative items/toys

- Paper towel/toilet paper rolls with food inside
- Paper bags with food inside
- Cardboard boxes with food inside
- Burlap bags with straw or treats
- Cornstalks
- Sod
- Snow piles
- Ice cubes
- Sleeping platforms
- Logs to climb on
- Wood box filled with stones/sod/straw to search for treats in
- Yellow pages, paper to shred
- Shredded paper, wood wool for bedding
- Hay from hoofstock exhibits
- Water tubs

Physical environment

- Sleeping platforms with bedding
- Digging boxes/pits
- Climbing structures
- Rock piles
- Deep dirt to tunnel in
- Hollow logs
- Stone piles
- Mud wallows

Behavioral/social

- Training programs
- Visual access to other species
- Climbing and digging opportunities