ASSOCIATION OF ZOOS & AQUARIUMS

MONGOOSE, MEERKAT, and FOSSA (*Herpestidae/Eupleridae*) CARE MANUAL

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

Mongoose, Meerkat, & Fossa (Herpestidae/Eupleridae) Care Manual

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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 nutritional and behavioral needs of all mongooses and fossas (AZA Accreditation Standard 2.6.2). Diets should be developed using the recommendations of nutritionists, the Nutrition Scientific Advisory Group (NAG) feeding guidelines: (http://www.nagonline.net/Feeding%20Guidelines/feeding_guidelines.htm), and veterinarians as well as AZA Taxon Advisory Groups (TAGs), and Species Survival Plan® (SSP) Programs. 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.

Herpestid and euplerid species consume a range of food items including vertebrates, eggs, fish, invertebrates, and some plant/vegetable matter (Gould & McKay, 1998; Macdonald, 1999; Nowak, 1999; Ray & Sunquist, 2001). Cusimanse (*Crossarchus obscurus*) forage on vertebrate prey, eggs, invertebrate prey, and fruit. This species is known to break eggs utilizing their forepaws positioned back between the hind feet and a hard object (Nowak, 1999). Fossas (*Cryptoprocta ferox*) are highly opportunistic feeders with hyena-like dentition (L. Dollar, personal communication, 2005), and will consume almost any vertebrates and some invertebrates they naturally encounter. Dwarf mongooses (*Helogale parvula*) mainly forage invertebrate prey along with small vertebrates, eggs, and fruit. Meerkats (*Suricata suricatta*) primarily forage invertebrate prey but also small vertebrate prey, eggs, and vegetable matter. Banded mongooses consume small vertebrates like birds, snakes, and rats; their diet also includes invertebrates, reptile, or bird eggs, and they reportedly eat fallen fruit.

Digestive System Morphology and Physiology: Dentition in these families is highly variable, reflecting food specialization of species within the families (Schliemann, 1990). Meerkats possess dentition with well-developed molar cusps for crushing chitinous exoskeletons, while banded mongooses have more pronounced crushing dentition as seen in carnivores (Schliemann, 1990).

The gastrointestinal tract of mongoose is reported to be quite similar to that of a domestic cat; however, the cecum is very rudimentary in some and absent others (Stevens & Hume, 1995).

Nutrient Requirements: Although many of the items consumed by these species are known, the nutrient content of these items has not been completely characterized. In many cases, target nutrient levels are based on those of well-studied carnivores and, to a lesser extent, omnivores (e.g., Arctic fox/mink and cats). 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 (Table 6). These values include cat requirements (NRC, 2006; Legrand-Defretin & Munday, 1993; AAFCO, 1994), Arctic fox/mink (NRC, 1982) requirements, and general mustelid guidelines (Maslanka et al., 1999). As additional information becomes available, these ranges should be adjusted to reflect new knowledge.

Meerkat: Taurine has been determined to be a necessary component to the diet of meerkats; lack of taurine may result in enlarged hearts and related complications. Diets should contain a form of cat food (which is rich in taurine), mice (which also contain taurine), or taurine dietary supplements (K. Kimble, personal communication, 2004 & 2005). See Appendix F for nutrient descriptions and Chapter 6: Veterinary Care for additional information.

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. Invertebrate-eating specialists in *Herpestidae* have low basal metabolic rates primarily due to their eating habits (McNab, 1989). Work done by Muñoz-Garcia & 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. Based upon this work Muñoz-Garcia and Williams (2005) concluded, "…species that eat meat have larger home ranges and higher BMR than species that eat vegetable matter."

Table 5: Basal Metabolic Rate (BMR) of Selected Herpestidae and Eupleridae Species (from: Muñoz-Garcia & Williams, 2005; citing original sources)

Species	Body Mass (g)	BMR (kJ/d)	Diet (%) Meat/Invert/Veg	Home Range (km^2)*
Herpestes sanguineus	540	194.4	36.5/63.4/0.1	Not listed
Herpestes auropunctatus	611	193.56 ± 149	50.7/25.5/22.4	Not listed
Suricata suricatta	850	148.92 ± 9	22.4/77.6/0	Not listed
Fossa fossa	2,260	435	50/50/0	Not listed

* Females only

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 included herein have supported all life stages. Goal weights for individuals should be established, and body weight checked frequently, so that diet adjustments can be made in a timely fashion to avoid over or under-condition.

Table 6: Target nutrient ranges for baseline species (dry matter basis)

Nutrient	More Carnivorous[1] Fossa, Meerkat, Dwarf Mongoose, Banded Mongoose
Protein (%)	19.7–32.5
Fat (%)	9.0–30
Linoleic Acid (%)	0.5–0.55
Vitamin A (IU/g)	2.44–10
Vitamin D (IU/g)	0.25–1.0
Vitamin E (mg/kg)	27–120
Thiamin (mg/kg)	1.0–5.6
Riboflavin (mg/kg)	1.6–4.25
Pantothenic acid (mg/kg)	5.0–8.0
Niacin (mg/kg)	9.6–60
Pyridoxine (mg/kg)	1.6–4.0
Folacin (mg/kg)	0.2–1.3
Biotin (mg/kg)	0.07–0.12
Vitamin B_{12} (mg/kg)	0.02–0.035
Calcium (%)	0.29–1.0[2a]
Phosphorus (%)	0.26–0.8[2a]
Potassium (%)	0.4–0.6
Sodium (%)	0.05–0.4
Magnesium (%)	0.03–0.08
Iron (mg/kg)	80–114
Zinc (mg/kg)	50–94
Copper (mg/kg)	5.0–8.8
Iodine (mg/kg)	0.35–2.2
Selenium (mg/kg)	0.1–0.4

[1] Cat NRC (2006), Legrand-Defretin & Munday (1993), Cat AAFCO (1994); Maslanka et al. (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] Authors of this chapter would caution feeding diets with 0.29% calcium and 0.26% phosphorus as the Cat NRC 2006 suggests.

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, each animal should be managed on an individual basis to avoid obesity. Group dynamics often play a role in the

nutrient content of the consumed diet, with animals consuming more or less energy, comparatively, based on their status in the dominance hierarchy.

Nutrition for alternate life stages/conditions: In general, diets should be formulated with the individual animal in mind, even for animals housed in groups. Diet adjustments should be based on condition of the animal in question, and can be applied for a variety of reasons — growth and development, gestation or lactation status, activity level, illness, and/or seasonal changes.

Age: Feeding should be observed to insure the subordinate animals receive the correct proportions of ingredients. Often increasing the number of feeding times per day, placing the food in several locations (particularly for meerkat and mongoose species), distracting some of the animals to allow others adequate access or visually separating animals are necessary in a group of animals.

Reproductive status: Total food quantity may need to be increased during pregnancy and lactation to maintain female body weight appropriately. Some weight loss may be appropriate (adipose mobilization to support lactation), but should be monitored regularly to ensure health of the female. In some cases calcium intake may also need to increase.

It is important to note that in dwarf mongoose, females typically produce multiple litters in succession so that they can be both pregnant and lactating at the same time. Producing up to four litters in 6 months, each averaging 22% of the female's body mass, has substantial energy requirements (Creel, 1996). As a result the female will likely need increased food quantity for successful reproduction and rearing of the young, particularly if the group size is small (C. McKnight, personal communication, 2010).

5.2 Diets

The formulation, preparation, and delivery of all diets must be of a quality and quantity suitable to meet the animal's psychological and behavioral needs (AZA Accreditation Standard 2.6.3). Food should be purchased from reliable, sustainable, and well-managed sources. The nutritional analysis of the food should be regularly tested and recorded.

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.

There is a wide range of diets that may be available to Euplerids and Herpestids (sample diets listed in Table 7). As omnivores and carnivores, diets that contain a mix of food items and groups appear most appropriate, with emphasis on vertebrate and invertebrate portions of the diet for more carnivorous members (e.g., fossa, meerkat, banded and dwarf mongoose). Ideally, a palatable, nutritionally complete food (wet or dry) may be used as the base of the diet to which other items are added as appropriate based on feeding strategy. Water should be available at all times. The nutrient profiles of these diets are listed in Table 6.

Table 7: Sample diet from AZA institutions of herpestid species as fed daily*

Species	Common Name	Institution	Food Item[1]	grams/day	% in diet
Cryptoprocta ferox	Fossa	Institution A	Natural Balance Carnivore 5%[1]	350	77.04
			IAMS weight control cat dry	100	22.01
			Mouse	4.3	0.94
			Femur Bone	-	-
			Total	454.3	100
		Institution B	Nebraska Special Beef Feline	225	64.68
			Ground Meat – beef, horse, bison	55	15.81
			Rat	42.8	12.32
			Bone	25	7.19
			Total	347.8	100
		Institution C	Nebraska Premium Beef	291	74.81
			Ground Meat - beef	61	15.66
			Rat	37	9.53
			Total	389	100
Suricata suricatta	Meerkat	Institution C	IAMS adult cat food dry	32	57.14
			Natural Balance Carnivore 10%	10	17.86
			Fruit – used apple	3	5.36
			Starch – used sweet potato	3	5.36
			Veggies – used carrot	7	12.50
			Crickets	1	1.79
			Total	56	100
		Institution D	Royal Canine Vet Diet Low Fat	15	43.23
			Fruit/Vegetable – used apple/carrot	7	20.17
			Oat cereal – Cheerios	7	20.17
			Fuzzy (6 grams) (2x/wk)	1.7	4.90
			Avocado	3	8.65
			Insects – used crickets	1	2.88
			Total	34.7	100
		Institution E	PMI Exclusive chicken dry	8.1	7.69
			PMI Exclusive chicken light dry	8.1	7.69
			Fruit – used apple	16.1	15.33
			Carrot	8.1	7.69
			Yam	8.1	7.69
			Natural Balance Carnivore 10%	32.4	30.72
			Mice	13.7	13.00
			Egg, hard-boiled	10.7	10.16
			Total	105.3	100
		Institution F	Totally Ferret, ground	5	6.39
			Fruit/Vegetable	40	51.16
			Mealworms	11	14.07
			Mouse	4.7	6.03
			Egg, hard-boiled	14.3	18.27
			Ground Meat – beef	2.8	3.65
			Calcium carbonate	0.33	0.42
			Total	78.13	100
		Institution G	IAMS less active cat dry	20	29.23
			ZuPreem Feline canned	10	14.61
			Fruit – used apple	8	11.69
			Root vegetable – sweet potato	20	29.23
			Capelin	2.3	3.34
			Mouse	2.1	3.13
			Egg, hard-boiled	4.6	6.68
			Natural Balance Carnivore 10%	1.1	1.67
			Mouse, pinkie	0.28	0.42
			Total	68.38	100

Helogale parvula	Dwarf Mongoose	Institution F	Eukanuba cat maintenance dry-chkn	7	19.92
			Crickets	3.5	9.96
			Mealworms	3.5	9.96
			Yam	5.6	15.85
			Corn	3.7	10.57
			Peas	3.7	10.57
			Mice, pinkie	1	2.85
			Egg, hard-boiled	7.1	20.33
			Total	35.1	100
		Institution A	IAMS less active cat dry	12.1	37.17
			Fruit – used apple	7.6	23.34
			Root Vegetable – used sweet potato	10.0	30.72
			Natural Balance Carnivore 5%	1.4	4.39
			Cricket	1.2	3.69
			Mealworm	0.23	0.70
			Total	32.53	100
		Institution B	EVO Feline Diet dry	4	8.51
			ZuPreem Feline canned	15	31.91
			Reliable Protein Product Insectivore	15	31.91
			Carrots – ground	2	4.26
			Sweet Potato – ground	2	4.26
			Egg, hard-boiled	6.4	13.68
			Mouse, hopper	2.6	5.47
			Total	47.0	100
Mungos mungo	Banded Mongoose	Zoo H**	Mealworms	10	13.51
			Chick	32	43.24
			Natural Balance Carnivore 5%	16	21.62
			Mazuri Insectivore dry	7	9.46
			Produce	9	12.16
			Total	74	100

[1]Natural Balance Pet Foods, Inc. Pacoima, CA 91331; P&G Pet Care (IAMS), Cincinnati, OH 45220; Marion Zoological, Plymouth, MN 55441; Central Nebraska Packing, Inc. North Platte, NE 69103; Waltham Royal Canine USA, Inc., St. Charles, MO 63301; PMI Nutrition, Henderson, CO 80640; Performance Foods, INC., Broomfield, CO 80021; ZuPreem; Shawnee, KS 66214; EVO Pet Products, Santa Clara, CA 95052; Reliable Protein Products, Phoenix, AZ 85050; Mazuri PMI Nutrition International. Brentwood, MO 63144.

* The AZA SCTAG does not specifically endorse the use of any mentioned products.

** Also feed one medium sized mouse per individual daily.

Table 8: Nutrient content of sample diets[1] (dry matter basis)

Institution	Institution A	Institution B	Institution C	
Nutrient	Fossa	Fossa	Fossa	More Carnivorous
Protein (%)	46.9	48.5	49.1	19.7–32.5
Fat (%)	16.5	39.1	40.8	9.0–30
Vitamin A (IU/g)	18.8	18.4	18.3	2.44–10
Vitamin D (IU/g)	2.3	0.68	0.85	0.25–1.0
Vitamin E (mg/kg)	304	294	329	27–120
Thiamin (mg/kg)	21.6	8.1	0.49[2]	1.0–5.6
Riboflavin (mg/kg)	22.6	1.2	0.85[2]	1.6–4.25
Pantothenic acid (mg/kg)	52.1	2.3	1.8	5.0–8.0
Niacin (mg/kg)	237	26.1	16.9	9.6–60
Pyridoxine (mg/kg)	19.8	2.0	2.3	1.6–4.0
Folacin (mg/kg)	1.5	0.05[2]	0.04[2]	0.2–1.3
Biotin (mg/kg)	1.4			0.07–0.12
Vitamin B_{12} (mg/kg)	0.24	0.07	0.10	0.02–0.035
Calcium (%)	1.6	1.44	1.49	0.29–1.0
Phosphorus (%)	1.1	1.03	0.85	0.26–0.8
Potassium (%)	0.73	0.77	0.79	0.4–0.6
Sodium (%)	0.52	0.43	0.26	0.05–0.4
Magnesium (%)	0.36	0.11	0.09	0.03–0.08
Iron (mg/kg)	166	100	434	80–114
Zinc (mg/kg)	168	85.6	109	50–94
Copper (mg/kg)	21.6	7.4[2]	9.7[2]	5.0–8.8
Iodine (mg/kg)	1.9			0.35–2.39
Selenium (mg/kg)	0.58	0.42	0.49	0.1–0.4

	Institution C	Institution D	Institution E	Institution F	Institution G	
Nutrient	Meerkat	Meerkat	Meerkat	Meerkat	Meerkat	More Carnivorous
Protein (%)	36.5	19.9	35.8	36.2	29.66	19.7–32.5
Fat (%)	23.7	9.0	21.6	21.9	15.89	9.0–30
Vitamin A (IU/g)	89.5	68.4	109	108.6	151	2.44–10
Vitamin D (IU/g)	2.3	0.98	0.65	1.17	1.86	0.25–1.0
Vitamin E (mg/kg)	149	162	374	109.1	124	27–120
Thiamin (mg/kg)	29.8	15.8	11.9	15.92	20.5	1.0–5.6
Riboflavin (mg/kg)	15.9	7.2	8.7	16.42	16.2	1.6–4.25
Pantothenic acid (mg/kg)	44.9	24.7	20.1	26.95	38.4	5.0–8.0
Niacin (mg/kg)	159	64.5	58.7	51.32	121	9.6–60
Pyridoxine (mg/kg)	22.1	11.6	7.9	12.06	15.7	1.6–4.0
Folacin (mg/kg)	5.8	6.99	9.3	2.03	2.5	0.2–1.3
Biotin (mg/kg)	0.91	1.9[2]	0.59	0.18	0.65	0.07–0.12
Vitamin B_{12} (mg/kg)	0.26		0.07	0.06	0.22	0.02–0.035
Calcium (%)	1.17	0.81	1.2	2.46	0.85	0.29–1.0
Phosphorus (%)	0.98	0.83	0.72	0.59	0.68	0.26–0.8
Potassium (%)	0.78	0.74	0.52	1.22	0.73	0.4–0.6
Sodium (%)	0.39	0.59	0.42	0.69	0.23	0.05–0.4
Magnesium (%)	0.12	0.10	0.15	0.34	0.08	0.03–0.08
Iron (mg/kg)	280	94.7	110	108.6	141	80–114
Zinc (mg/kg)	223	41.4	109	110.8	181	50–94
Copper (mg/kg)	29.5	3.7	11.1	10.48	15	5.0–8.8
Iodine (mg/kg)	2.3	0.31	0.85	0.56	1.8	0.35–2.2
Selenium (mg/kg)	0.57	0.15	0.20	0.4	0.38	0.1–0.4

	Institution F	Institution A	Institution B	
Nutrient	Dwf Mongoose	Dwf Mongoose	Dwf Mongoose	More Carnivorous
Protein (%)	34.4	26.8	40.6	19.7–32.5
Fat (%)	15.9	10.5	24.2	9.0–30
Vitamin A (IU/g)	15.2	142	58.9	2.44–10
Vitamin D (IU/g)	1.3	2.1	0.73	0.25–1.0
Vitamin E (mg/kg)	80.1	126	108	27–120
Thiamin (mg/kg)	14.8	21.4	9.45	1.0–5.6
Riboflavin (mg/kg)	11.8	15.0	10.02	1.6–4.25
Pantothenic acid (mg/kg)	28.4	35.9	20.3	5.0–8.0
Niacin (mg/kg)	82.9	127	59.0	9.6–60
Pyridoxine (mg/kg)	12.2	17.1	3.7	1.6–4.0
Folacin (mg/kg)	1.8	2.2	0.97	0.2–1.3
Biotin (mg/kg)	0.41	0.68	0.27	0.07–0.12
Vitamin B_{12} (mg/kg)	0.17	0.25	0.17	0.02–0.035
Calcium (%)	0.54	0.79	0.88	0.29–1.0
Phosphorus (%)	0.67	0.66	0.64	0.26–0.8
Potassium (%)	1.0	0.79	0.37	0.4–0.6
Sodium (%)	0.24	0.23	0.22	0.05–0.4
Magnesium (%)	0.10	0.10	0.04	0.03–0.08
Iron (mg/kg)	101	131	150	80–114
Zinc (mg/kg)	149	185	98.9	50–94
Copper (mg/kg)	14.4	16.4	8.9	5.0–8.8
Iodine (mg/kg)	1.2	1.88	1.4	0.35–2.2
Selenium (mg/kg)	0.49	0.43	0.36	0.1–0.4

	Zoo H	
Nutrient	Banded Mongoose	More Carnivorous
Protein (%)	48.9	19.7–32.5
Fat (%)	20.1	9.0–30
Vitamin A (IU/g)	7.6	2.44–10
Vitamin D (IU/g)	1.4	0.25–1.0
Vitamin E (mg/kg)	182	27–120
Thiamin (mg/kg)	33.1	1.0–5.6
Riboflavin (mg/kg)	12.1	1.6–4.25
Pantothenic acid (mg/kg)	20.2	5.0–8.0
Niacin (mg/kg)	93.7	9.6–60
Pyridoxine (mg/kg)	8.8	1.6–4.0
Folacin (mg/kg)	1.3	0.2–1.3
Biotin (mg/kg)	0.51	0.07–0.12
Vitamin B_{12} (mg/kg)	0.1	0.02–0.035
Calcium (%)	1.2	0.29–1.0
Phosphorus (%)	1.0	0.26–0.8
Potassium (%)	0.36	0.4–0.6
Sodium (%)	0.24	0.05–0.4
Magnesium (%)	0.19	0.03–0.08
Iron (mg/kg)	171	80–114
Zinc (mg/kg)	111	50–94
Copper (mg/kg)	15.5	5.0–8.8
Iodine (mg/kg)	0.93	0.35–2.2
Selenium (mg/kg)	0.18	0.1–0.4

[1]Target nutrient levels listed in Table 7.
[2] Missing values in database so nutrients most likely meet targets.

General Food and Water Recommendations: Water and feeding stations should be located off the ground, in the branches or trees, for arboreal species. Water can be provided in a bowl or water bottles. All individuals should be observed to ensure that they know how to use the water bottle. Food can be

offered in a non-tippable container, placed to minimize the impact of dominance hierarchies, if group-fed. Enrichment items may be scattered to encourage foraging.

Typically, animals should be fed in accordance with their species-typical activity pattern, i.e., nocturnal animals fed prior to their 'night' (which can be reversed for exhibition purposes), and diurnal animals fed in the morning. Some species benefit from more frequent feedings with the added bonus that this also can raise the activity level in an exhibit (meerkat exception below), and a minimum of two feedings is recommended (AZA Small Carnivore TAG). An effective method is to provide the primary diet in one or two feedings and scheduled enrichment feedings that can be scattered to encourage foraging/hunting during public hours. All food enrichment should be included when energy intake for the total diet is determined. All feeding times should be variable to minimize anticipatory behavior and stereotypies developed at feeding/enrichment times.

The provision of species appropriate enrichment items, including food, is advisable. Food items used as enrichment should be included as part of the diet, varied in terms of content when they are offered, and presented in such a way as to encourage species-typical foraging activities (e.g., on the ground, in the trees, hidden in holes, etc.). Live insects, fruit pieces, kibble, and frozen mice are just some of the food items that have been used. Consider that food-based enrichment should revolve around novel ways to present the base diet, not necessarily increasing the variety of the diet as it exists.

In general, it is recommended to offer the diet in several feedings over the course of the day (see below for meerkat exception). Offering several meals will allow for more opportunities to adequately distribute food items to animals within a group. A minimum of two feedings per day is recommended; this includes any enrichment feedings (AZA Small Carnivore TAG recommendation). Food should be offered in containers that are cleaned and sanitized after each use. Remnants of food scattered/hidden as enrichment should be removed.

Banded mongoose: Zoo H gives banded mongoose 9 grams of 3/4 inch crickets each or 9 grams of waxworms each. Each mongoose also gets 1 medium mouse in addition to the items listed previously. Banded mongoose are an omnivorous species. Food is always scattered around to help with aggression and the insect part of their diet is offered in puzzle feeders which keeps them entertained for hours.

Fossa: Fossas are strictly carnivorous and can be fed a variety of different food items approximating 0.5–1.0 kg (1.1–2.2 lbs) per animal per day (Winkler, 2002). Fossas have generally been fed once a day, but this amount can be divided into several, smaller feedings throughout the day and hidden/scattered in the exhibit to encourage foraging/hunting behavior; larger items such as rodents can be hung from branches etc. (Winkler, 2002).

In situ fossas will not eat carrion (L. Dollar, personal communication, 2005), so wild caught animals may be resistant to consuming dead food. In these cases, they will initially have to be fed live prey until they make the transition. However, in general, fossas should be fed a variety of whole carcass foods whenever possible; these can include: mice, rats, day-old chicks, chicken, and meat with bone (Winkler, 2002).

Meerkat: In stable groups, at least one feeding station should be provided for every three individuals. In non-stable groups, or groups in which food aggression has been observed there should be at least one feeding station for each individual in the group with feeding stations distributed in such a way that no one individual can monopolize more than one feeding station. Scattering diet items and/or multiple feeding stations are the most effective ways to feed a large group of meerkats. When offering enrichment items, there should be at least one item for each individual to prevent aggression, and items should be spread out as much as possible.

The primary part of the diet should be fed in the morning, allowing animals to eat throughout the day. Whole prey items (e.g., mice, ribs) and live bugs (mealworms and crickets) can be fed in the afternoon/early evening or at scattered enrichment times. Care should be taken when feeding whole prey that each individual receives an item, thereby minimizing opportunities for aggression (K. Kimble, personal communication, 2004 & 2005).

Initial introduction of food can stimulate aggression amongst meerkats; therefore, it is recommended that they be offered the majority of their diet once daily, in the morning. If a schedule of multiple, small feedings is adopted the provision of less food more often may stimulate unnecessary aggression leading to social unrest (K. Kimble, personal communication, 2004 & 2005).

Generally, meerkats will not finish all of their diet at one feeding, instead visiting feeding stations throughout the day. Dominant animals tend not to guard food locations for long periods of time, thus allowing subordinate individuals an opportunity to eat once more dominant individuals are satiated and tire of protecting feeding stations. Whole prey and insects may be fed later in the day to promote activity and foraging behavior. Again, when providing enrichment items it is important that enough individual items are offered to allow foraging participation by the entire group (K. Kimble, personal communication, 2004 & 2005).

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 should be processed following all USDA standards. The appropriate hazard analysis and critical control points (HACCP) food safety protocols for the diet ingredients, diet preparation, and diet administration should be established for the taxa or species specified. Diet preparation staff should remain current on food recalls, updates, and regulations per USDA/FDA. Remove food within a maximum of 24 hours of being offered unless state or federal regulations specify otherwise and dispose of per USDA guidelines.

AZA Accreditation Standard

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

AZA Accreditation Standard

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

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 mongoose and fossa. 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.

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 rather than using generic male/female body weights. Some individuals tend toward obesity, and season and activity patterns can influence consumption and subsequent body condition. For these reasons, "goal weights" should be established for individuals (in general or on a seasonal basis), and body weights checked frequently, so that diet adjustments can be made in a timely fashion to avoid over- or under-conditioning.

group, it is always dangerous to separate individuals from their group due to possible re-introduction challenges. It is important for the other group members to be able to interact with the pups and perform species-typical behaviors such as babysitting. Furthermore, a dam that does not have other individuals to help with the care of the pups may not leave the pups in the den to fulfill her own basic needs such as eating and drinking.

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 staff in AZA-accredited institutions are able to assist with the rearing of these offspring if necessary.

There has not been much experience in hand-raising these species because if hand-raised, the social herpestids seldom breed (Carnio, 1996a; 1996b). Hand-rearing protocols, including when and if abandoned or failing young should be pulled, should be established in advance. This plan also should establish who will care for the young, formula to be fed, and how the young will be socialized with conspecifics.

Banded mongoose: This species has been successfully hand-reared. The following guidelines were provided by C. Bickel:

Formula: Esbilac®, puppy milk replacer (used pre mixed liquid 8 oz cans).
To avoid complications with diarrhea caused by a change in milk, start with a dilute formula.

- First 24 hours fed 1/4 strength formula: 1 part liquid Esbilac® - 3 parts sterile water
- Day 2 fed 1/2 strength formula: 2 parts liquid Esbilac® - 2 parts filtered water
- Day 3 fed 3/4 strength formula: 3 parts liquid Esbilac® - 1 part filtered water
- Day 4 fed full strength formula: full strength Esbilac®
- Additives: Lactace, lactobilcillus blend, vitamin E
- First day pups may need to feed more frequently because of the diluted formula, as formula concentration increases pups will feed less frequently.

Amount fed: 20–25 % body weight per day, divided into eight feedings, Fed ad-lib or every 2 hours. This was done to avoid diarrhea from over feeding, Over loading of the gut can cause diarrhea, bloat, gut stasis and possibly death.

Feeding apparatus: "CATAC" nursing nipple

- Small-straight with 3 cc syringe until 8 days of age then switch to:
- "CATAC" medium-tapered (they are growing fast), (UPCO 1-800-254-8726, item number 391 small-straight nipple and item number 392 medium-tapered).

Weaning:

- 19 days of age: hand fed waxworms.
- 21 days of age: introduced solid food. Gerber's Tender Harvest Chicken + Wild Rice, licked from tip of nipple.
- 26 days of age: eating canned kitten food/chicken, Nutro Natural Choice, Complete Care.
- 36 days of age: Insectivore kibble added to milk and canine diet mixture.
- Weaned from nipple or syringe feeding at 31 days of age, but Esbilac formula was mixed with canine diet and eating from bowls.
- 32 days of age: drinking water from bowl, canned cat food discontinued and switched to Nebraska Brand Canine Diet mixed with Esbilac formula.

Medical problems: Bite wounds, pimples mostly around head, although there are pimples on other parts of their body and juvenile Diabetes Mellitus. Wounds were treated with “Animax” and A + D ointment applied to dry skin. Toenails were clipped at 9 days of age to prevent scratches.

Physical development:

- 7 days of age: eyes open.
- 10 days of age: defecating on own and using a litter pan at 29 days of age.
- 11 days of age: can see. Ears starting to open.
- 14 days of age: canines erupted and cheek teeth at 18 days of age.
- 15 days of age: perching on tail, a bit unstable.

- 16 days of age: following caretaker around on the floor, exercised for 5 minutes before returned them to the incubator, they were easily chilled. Playful, wrestling at this age.
- 28 days of age: Sleeping through the night, may no longer need night feedings. Moved out of incubator and onto floor of nursery room. Furnished with hay, litter pan, blankets, fuzzies, and heat lamp for added warmth.
- 31 days of age: discontinued nipples, and the animals eating from bowls.
- 32 days of age: grooming themselves.
- 36 days of age: eating crickets, mealworms, and waxworms.
- 38 days of age: scent marking everything.

Dwarf mongoose: Staff have successfully been hand-reared this species and reintroduced the young to a group; in one case one of the hand-reared females became the dominant female and produced her own pups which were raised successfully (C. Brown, personal communication, 2006).

Fossa: Fossas have been hand-raised several times primarily due to inappropriate mother behavior. First-time mothers have a high incidence of cannibalism and should have a quiet, secure place to raise their offspring. Any disturbances can cause the female to become increasingly anxious and may result in loss of the pups. Even when it appears that everything needed has been offered, the mother may still exhibit behaviors including frantically relocating pups over and over, abandoning, or even consuming the pups. If hand-rearing is necessary, Esbilac with Taurine and Lactase enzyme added has been used successfully as a milk replacer. The formula can be delivered in a 4 oz Petag nurser bottle with 22-gauge needle hole in the nipple. The Program Leader can be contacted directly for specific information on a successful hand-rearing protocol.

Meerkat: Due to the extremely social nature of this species, it is not recommended that individuals be hand-reared (AZA Small Carnivore TAG recommendation). Hand-reared pups may become aggressive toward caregivers as they get older, and do not make good ambassador animals. In one case, 26-day-old pups in need of medical treatment were successfully given supplemental feedings. During this period the pups were left with the group, indicating that this method may be an alternative to hand-rearing compromised pups without removing them from the group (K. Kimble, personal communication, 2004 & 2005).

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 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 herpestids are outlined below. More details on products, application, and ordering information can be found on the AZA Wildlife Contraception Center (WCC) webpage: http://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 (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 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 meerkats and banded mongoose.

Gonadotropin releasing hormone (GnRH) agonists: GnRH agonists (e.g., Suprelorin® implants, or Lupron Depot®) achieve contraception by reversibly suppressing the reproductive endocrine system, preventing production of pituitary (FSH and LH) and gonadal hormones (estradiol and progesterone in females and testosterone in males). 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

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Appendix F: Description of Nutrients (U.S. National Library of Medicine)

Protein: Protein is the main building block 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 is also 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. Fat also 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 sexes. 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; 285-315 nm; Bernard, 1997).

Vitamin E: Vitamin E is a fat-soluble antioxidant which helps to maintain the structure of cellular and sub-cellular 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 carbohydrate in the diet.

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 convert energy from food. The niacin requirement of many animals could theoretically 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 is also necessary 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 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 defense against infection.

Zinc: Zinc is also 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 is also involved in the metabolism of carbohydrates. Zinc is essential for synthesis of DNA, RNA, and proteins, and 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 helps reduce the risk of osteoporosis. Manganese also helps produce certain hormones, metabolizes fat, and is part of superoxide dismutase (SOD), an antioxidant. Studies on humans have shown that manganese may also lower the frequency of epileptic seizures and enhance immune function.

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 keep 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. Its main role is 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 may also 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 G:
AAZK, Inc. Enrichment Committee, Enrichment Caution List

Dietary Enrichment

- Food enrichment, if uncontrolled, can lead to obesity, tooth decay; deviation from the normal diet can cause nutritional problems. Keepers can consult with the nutritionist or commissary staff to determine the best method of introducing novel food items.
- New food items introduced without analysis may cause colic, rumenitis, or metabolic acidosis in ungulates.
- Food items can spoil and cause animal illness if left in the exhibit for extended periods of time. Enrichment food items should be removed within a reasonable amount of time to prevent spoilage.
- Animals can have adverse reactions to toxic plants and chemicals. Keepers should be able to correctly discern between toxic and browse plants, ensure that browse is free of fertilizers and herbicides, and wash plants to remove free ranging bird and animal feces and debris.
- Foraging or social feedings may give rise to aggression and possible injuries within the animal population.
- Competition for enrichment items may lead to social displacement of subordinate animals. These concerns can be minimized by providing enough enrichment to occupy all of the animals within the population.
- Carcass feedings for omnivores and carnivores may be hazardous if the source of the carcass is not determined and appropriate precautions taken. Diseased animals, chemically euthanized animals or those with an unknown cause of death are not appropriate for an enrichment program. Freezing the carcasses of animals that are determined to be safe to feed to exhibit animals can help minimize the risk of parasitism and disease. Providing enough carcasses in group feedings can minimize competition and aggression within an exhibit.
- Carefully introducing a group of animals to the idea of social feedings can be done by moving carcass pieces closer together at each feeding until the animals are sharing one carcass. This can allow social carnivores to exhibit normal dominance posturing while minimizing the possibility of aggression.
- Cage furniture may interrupt flight paths or entangle horns and hooves if poorly placed. Careful planning can prevent this.
- If unsecured, some items may fall on an animal or be used as a weapon and cause injuries.
- If position is not thoughtfully considered, limbs and apparatus may provide avenues for escape or may block access into exhibit safety zones, leaving subordinate animals feeling trapped and vulnerable.
- Animals that crib or chew wood should be provided with non-toxic limbs and untreated wood furniture.
- Water features should be tailored to the inhabitants to prevent drowning and ensure that animals such as box turtles can right themselves if they flip over on their backs.
- Animals can be injured in filtration systems if water intake areas are not protected.
- Substrates should provide adequate traction and not cause an intestinal impaction if ingested.
- Caution should be exercised when ropes, cables, or chains are used to hang or secure articles to prevent animals from becoming entangled. Generally, the shortest length possible is recommended. Chain can be covered with a sheath such as PVC pipe; swivels can be used to connect the chain to the enrichment item to minimize kinking.

Olfactory Enrichment

- Scents from different animals or species can lead to aggression if there is an assertion of dominant animals or subordinate animals attempting to use enrichment to advance their status in the hierarchy.
- Animal feces used for olfactory enrichment should be determined to be parasite free through fecal testing and as with other animal by-products such as feathers, sheds, wool and hair, come from only healthy animals. Many of these items can be autoclaved for sterilization.

- Perfumes can be overwhelming to some animals (and keepers) and are therefore best used in open, ventilated areas.
- Some spices may be too strong or toxic to some animals.

Auditory Enrichment

- When provided with audio enrichment, animals may be less threatened by deflected sounds rather than those directed at the animals.
- Some animals may have adverse reactions to recordings of predator calls and should be closely observed when this type of enrichment is provided.
- Providing the animals with an option for escape or the means to mobilize for confrontation when predator calls are played can lessen the stress of this type of enrichment and allow the animals to investigate the sounds and their environment over a period of time.

Manipulable Enrichment

- Individual parts or enrichment devices may be swallowed resulting in choking or asphyxiation.
- If ingested, indigestible enrichment items may cause a gut impaction or linear obstruction.
- Broken items may have sharp edges that can cut an animal. Only items that are appropriate for the species should be provided. For example, some devices will hold up to the play of a fox but not a wolf.
- When building or designing enrichment items from wood, it may be wise to use dovetail cuts and glue rather than screws and nails. Rounded corners and sanded edges can prevent the animals from getting splinters.
- Many paints and other chemicals are toxic if eaten. When providing enrichment involving paint or other chemicals, only non-toxic items should be used.
- Destructible items such as cardboard boxes and paper bags should be free of staples, tape, wax, strings, or plastic liners.