ASSOCIATION OF ZOOS & AQUARIUMS

VIVERRID
(*Viverridae*)
CARE MANUAL

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

Viverrids (Viverridae) 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

A formal nutrition program is recommended to meet the behavioral and nutritional needs of all viverrids (AZA Accreditation Standard 2.6.2). Diets should be developed using the recommendations of nutritionists, AZA Taxon Advisory Groups, Species Survival Plans®, the Nutrition Advisory Group's feeding guidelines (www.nagonline.net/feeding_guidelines.htm), and qualified veterinarians. 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.

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.

Digestive System Morphology and Physiology: The gastrointestinal tract of Viverridae are reported to be quite similar to that of a domestic cat, however, the cecum is very rudimentary in at least some of the viverrids (Stevens & Hume 1995), and absent in the binturong (Crapo et al. 2002). The cat gastrointestinal tract is relatively short and the hindgut contains a small cecum and unsacculated colon. See Kawahty et al. (2003) for a discussion of viverrid digestive physiology.

Crapo et al. (2002) postulated that "….the characteristics of the GIT suggest that the binturong may be unable to digest and utilize fruits as efficiently as most monogastric animals with a cecum do. Considering that the binturong is known to ingest fruits in its natural habitat, it is possible that such fruits serve as a main source of water and that binturongs may require the ingestion of a large volume of fruits and other feeds to meet its nutritional requirements." Further research is needed to better understand this and other aspects of binturong nutritional needs.

Nutrient Requirements: Whereas nutritional requirements for the viverrid species are not currently available, target nutrient values are proposed. Although many of the items consumed by viverrids are known, the nutrient content of these items has not been completely characterized. In the case of viverrids, target nutrient levels are based on those of well-studied carnivores and omnivores (dogs, 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, the highest values reported are reflected. 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 5). These values are provided in comparison to straight cat (NRC 1986; Legrand-Defretin & Munday 1993; AAFCO 1994), dog (NRC 1974; AAFCO 1999), and Arctic fox/mink (NRC 1982) requirements. As additional information becomes available, these ranges should be adjusted to reflect new knowledge. In 2005 the National Research Council of the National Academies (dels.nas.edu/banr/petdoor.html) published updated information on the nutritional needs of cats and dogs. This new report "provides nutrient recommendations based on physical activity and stage in life, major factors that influence nutrient needs." This information is assimilated into Table 5 as well. See Appendix G for a description of nutrients.

Table 5: Target nutrient ranges for baseline species (dry matter basis)

Nutrient	More Omnivorous[1] Binturong	More Carnivorous[2] Owston's Palm Civet and Genet
Protein (%)	17.5-26.0[1a]	19.7-32.5
Fat (%)	5-8.5	9.0-30[2a]
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 (%)	0.3-1.2[1b]	0.29-1.0[2c]
Phosphorus (%)	0.3-1.0[1b]	0.26-0.8[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] Authors of this chapter are not comfortable recommending a 10% protein for maintenance as the Dog NRC 2006 suggests.

[1b] Authors of this chapter would caution feeding diets with 0.3% calcium and/or phosphorus as the Dog NRC 2006 suggests.

[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.

[2c] Authors of this chapter would caution feeding diets with 0.29% calcium and 0.26% phosphorus as the Cat NRC 2006 suggests.

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. *Derbyanus* tend to have low metabolism because they feed principally on invertebrate prey, fruit or a combination of these food items, not simply because they are viverrids. Gittleman & Oftedal (1987) reported that frugivorous carnivores such as binturong have a low basal metabolic rate and a low growth rate due to their foraging habits (McNab 1989). 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 6). 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." Nagy et al (1998) propose that a reasonable equation to calculate BMR for omnivorous species is KJ/d = 6.03 BWg ^ 0.678), but a viverrid specific equation has not been developed.

Table 6. Basal Metabolic Rate (BMR) of Selected Viverridae Species [1]

Species	Body Mass (g)	BMR (kJ/d)	Diet (Meat %/Invert %/Veg %)	Home Range (km^2) (females only)
Arctictis binturong	14,280 ± 3,514	541.5 ± 192	20/0/80	Not listed
Genetta tigrina	1,698 ± 271	358.62 ± 16	68.1/31.8/0.1	0.06
Genetta felina	1,203.2 ± 191	286.46 ± 25	Not listed	Not listed
Nandinia binotata	4,270	414.02	15.1/24.4/43.6	0.45
Paradoxurus hermaphroditus	3,160	365.55	23.1/9.4/67.5	3.2
Arctogalidia tirvigata	2,010 ± 260	265.32 ± 76	0/10/90	Not listed

[1] Munoz-Garcia and Williams, 2005

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.

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.

AZA Accreditation Standard

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

Typically browse is not a dietary item for viverrid species. However, all plant items used in or around exhibits or those used for enrichment should be cleared by institutional management including the nutritionist, veterinarian, and horticulturists. If there are any questions regarding the safety of a plant it should not be used.

Diet Composition: The family Viverridae consists of binturong, civets, genets, and linsangs. This family ranges from mostly omnivorous to insectivorous or carnivorous. For example, Owston's civets (*Chrotogale owstoni*) have long narrow snouts and feed mostly on invertebrate prey, consuming some fruit and vertebrate prey as well (Gould & McKay 1998; Nowak 1999). Banded palm civets (*Hemigalus derbyanus*) are very carnivorous, foraging at night on the ground and in trees and consuming invertebrate and vertebrate prey (MacDonald 1999). Large spotted civets (*Viverra megaspila*) forage on small vertebrate prey, eggs, invertebrate prey, fruit, and vegetation (Nowak 1999). The banded linsang (*Prionodon linsang*) are small, quick, trimly built, secretive forest animals with banded tails. They depend almost entirely on small vertebrates as their diet, along with consuming some invertebrate prey (MacDonald 1999). The binturong (*Arctictis binturong*) has a massively muscular tail that, along with the hind-feet, is used to grasp branches while the forelimbs pull fruiting branches to the mouth (MacDonald 1999). Binturongs also have been reported to swim in water and catch fish (Nowak 1999). For the most part, all species in this family consume small mammals, fruit, and insects. Obesity in zoos is a common problem for viverrids (Denver 2003).

There are a wide range of diets that may be available to viverrids. As omnivores and carnivores, diets that contain a mix of food items and groups appear most appropriate, with emphasis added toward vertebrate and invertebrate portions of the diet for more carnivorous members (*Derbyanus* and *Linsang*). Based on the species in question, viverrid diets can consist of a commercially available, nutritionally complete meat product (moist or dry), fruits and vegetables, and occasional whole prey, eggs, and

insects. Many viverrid species not addressed in these guidelines (not maintained in AZA institutions) may require specific diets that should be thoroughly researched for current practices prior to acquisition (Carnio 2003). Example diets from AZA institutions are provided in Table 7, and their respective nutrient contents are listed in Table 8.

Civets: Civets should be provided with nutritionally complete, commercially available feline diet, rodents, fruits, day-old chicks, etc. Ideally, across the family, a palatable nutritionally complete food may be used as the base of the diet, to which other items can be added as appropriate and based on feeding strategy. A diet offered to Owston's civets at a facility in Viet Nam is listed in Table 9, but no nutrient content information is available. This facility has housed this species successfully for over ten years. These items are fed three times a night; items are either scattered or fed in enrichment devices. Food bowls are only used in quarantine quarters (Roberton et al. 2002). One item is selected from each food group daily.

Banded linsangs: For banded linsangs, a diet of ground meat with vitamins and minerals (commercially available meat mixes), fruits, vegetables, whole animals, eggs, and some insects may be appropriate (Carnio 1996).

Binturongs: Binturong diets should consist of a wide variety of fruits, vegetables, seeds, and a commercially available, nutritionally complete meat product. The addition, several times a week, of small or large carnivore kibble as a supplement to the meat fed binturongs has led to good health and excellent coat quality (M. Stinner, personal communication). Sweet foods such as bananas may be preferred, but every effort should be made to encourage consumption of a balanced diet that meets the target nutrient values discussed later in this chapter. Binturong also will readily eat raw (caution should be exercised) or cooked meat as a training treat or enrichment. Binturong should be fed daily, with no fast days (C. Schultz, personal communication). In the past, many facilities fed a very low level of protein to binturong that may have resulted in health issues associated with hypoproteinemia (A. Moresco, personal experience). Yogurt and natural/organic peanut butter (to avoid the added sugars of commercial peanut butters) were used as additional sources of protein for the binturong diets in that case. The target nutrient values in Table 5 are designed to avoid this occurrence. Due to their heavy coat, it is recommended that this species be handled or weighed regularly to monitor for weight gain or loss.

The AZA Nutrition Advisory Group cautions against feeding raw meat due to significant food sanitation concerns associated with the practice. If chosen as a food item, raw meat should only come from lab raised carcass foods or parasite free thawed meat (verified by independent screening). The AZA SCTAG recommends that facility policy be set in conjunction with the nutritionist, animal care staff, and veterinary staff, taking into consideration safety of food sources, animal health, and institutional policies. Young binturongs have been known to consume spoiled meat; care should be taken to remove all meat products before they become rancid (M. Stinner, personal communication).

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

Species	Common Name	Institution	Food Item[1]	grams/day	% in diet
Arctictis binturong	Binturong	Institution B	Pro-Plan chicken and rice canine[1]	208	42.3
			Fruit used apple	188	38.2
			Vegetables used carrot	46	9.3
			Natural Balance Carnivore 5%	50	10.2
			Total	492	100
		Institution C	IAMS chunk dog food	60	11.8
			Marion Leafeater gorilla size	60	11.8
			Natural Balance Carnivore 5%	35	6.9
			Root Vegetable used carrot	130	25.5
			Fruit used apple	200	39.2
			Egg, hard-boiled	25	4.8
			Total	510	100
		Institution D	Mazuri Primate Basix	60	10.0
			ZuPreem Feline Canned	60	10.0
			ZuPreem Primate canned	60	10.0
			Fruit Mix[2]	288	48.0
			Vegetable Mix[2]	120	20.0
			Grapes	12	2.0
			Total	600	100
Chrotogale owstoni	Owston's civet	Institution E	ZuPreemFeline Canned	8	4.3
			Fruit, mixed used apple	60	32.0
			Mouse	24.5	13.1
			Natural Balance Carnivore 10%	95	50.6
			Total	187.5	100
		Institution F	Mouse	10.7	8.4
			Earthworms	14.0	11.0
			IAMS cat food adult	25.0	19.6
			Natural Balance Carnivore 10%	45.4	35.5
			Sweet Potato	6.5	5.1
			Grapes	6.5	5.1
			Orange	6.5	5.1
			Apple	6.5	5.1
			Banana	6.5	5.1
			Total	127.6	100
		Institution D	IAMS adult weight control cat dry	15	9.3
			Natural Balance Carnivore 10%	31	19.1
			ZuPreem Feline Canned	20	12.3
			Fruit Mix[2]	71	43.8
			Mouse	16	9.9
			Cricket	6	3.7
			Mealworm	3	1.9
			Total	162	100
Genetta tigrina/genetta	Genet	Institution D	IAMS cat food adult	40	47.2
			Mouse	12.8	15.3
			Natural Balance Carnivore 5% Bone Marrow 2x/wk	30	35.4
			Mealworms	1.8	2.1
			Total	84.6	100
		Institution C	Nebraska Premium Beef Feline	85	57.0
			Chick	32	21.5
			Mouse	32	21.5
			Total	149	100

[1] ProVision, Pet Specialty Enterprises, Ralston Purina, St. Louis, MO 63164; Natural Balance Pet Foods, Inc. Pacoima, CA 91331; P&G Pet Care (IAMS), Cincinnati, OH 45220; Marion Zoological, Plymouth, MN 55441; PMI Nutrition International. Brentwood, MO 63144; Zupreem; Shawnee, KS 66214; Central Nebraska Packing, Inc. North Platte, NE 69103.

[2]Fruit mix is a combination of 16.26% apple, 27.49% banana, 6.71% grape, 3.47% orange, 6.35% papaya, 11.73% pear, 4.27% white potato, 13.63% sweet potato, 6.76% carrot, and 3.33% hard-boiled egg; Vegetable mix is a combination of 11.15% apple, 6.15% carrots, 8.92% pear, 1.44% collard greens, 6.34% green beans, 3.70% kale, 13.74% romaine, 10.94% pear, 9.87% white potato, 5.21% spinach, and 22.54% sweet potato.

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

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

Nutrient	Institution B Binturong	Institution C Binturong	Institution D Binturong	More Omnivorous
Protein (%)	26.0	22.0	18.4	17.5-26.0
Fat (%)	16.6	9.1	9.3	5-8.5
Vitamin A (IU/g)	73.5	222	96.4	0.5-5.9
Vitamin D (IU/g)	2.2	1.3	2.8	0.5-0.55
Vitamin E (mg/kg)	90.5	157	162	27-50
Thiamin (mg/kg)	36.2	10.7	21.6	1.0-2.25
Riboflavin (mg/kg)	19.7	10.5	11.0	1.6-10.5
Pantothenic acid (mg/kg)	42.2	33.2	10.7	7.4-15.0
Niacin (mg/kg)	135	80.2	86.8	11.4-20.0
Pyridoxine (mg/kg)	13.4	9.4	11.5	1.0-1.8
Folacin (mg/kg)	4.1	1.1	5.6	0.18-0.5
Biotin (mg/kg)	0.24	0.37	0.34	0.1-0.12
Vitamin B_{12} (mg/kg)	0.2	0.09	0.04	0.022-0.035
Calcium (%)	1.16	1.08	0.68	0.3-1.2
Phosphorus (%)	0.87	0.84	0.50	0.3-1.0
Potassium (%)	0.65	1.04	1.0	0.4-0.6
Sodium (%)	0.40	0.38	0.23	0.04-0.3
Magnesium (%)	0.13	0.19	0.11	0.04-0.06
Iron (mg/kg)	260	155	192	30-90
Zinc (mg/kg)	194	133	84.4	50-120
Copper (mg/kg)	15.4	22.6	14.1	6.0-12.4
Iodine (mg/kg)	1.7	1.1	1.01	0.9-1.54
Selenium (mg/kg)	0.04[2]	0.34	0.20	0.1-0.35

Nutrient	Institution E Civet	Institution F Civet	Institution D Civet	More Carnivorous
Protein (%)	42.8	39.9	34.5	19.7-32.5
Fat (%)	24.3	22.8	19.1	9.0-30
Vitamin A (IU/g)	11.4	12.7	43.7	2.44-10
Vitamin D (IU/g)	1.0	1.6	1.2	0.25-1.0
Vitamin E (mg/kg)	240	175	150	27-120
Thiamin (mg/kg)	8.2	18.7	13.6	1.0-5.6
Riboflavin (mg/kg)	13.3	13.5	13.3	1.6-4.25
Pantothenic acid (mg/kg)	25.0	32.8	28.7	5.0-8.0
Niacin (mg/kg)	99.1	122	99.8	9.6-60
Pyridoxine (mg/kg)	9.2	15.9	12.2	1.6-4.0
Folacin (mg/kg)	18.7	10.9	7.5	0.2-1.3
Biotin (mg/kg)	1.1	0.95	0.73	0.07-0.12
Vitamin B_{12} (mg/kg)	0.09	0.17	0.13	0.02-0.035
Calcium (%)	1.59	1.37	1.0	0.29-1.0
Phosphorus (%)	0.94	0.95	0.63	0.26-0.8
Potassium (%)	0.35	0.55	0.71	0.4-0.6
Sodium (%)	0.71	0.49	0.38	0.05-0.4
Magnesium (%)	0.23	0.17	0.15	0.03-0.08
Iron (mg/kg)	141	428	127	80-114
Zinc (mg/kg)	166	196	156	50-94
Copper (mg/kg)	14.4	22.2	14.6	5.0-8.8
Iodine (mg/kg)	0.66	1.4	1.2	0.35-2.2
Selenium (mg/kg)	0.14	0.41	0.24	0.1-0.4

Nutrient	Institution C Genet	Institution D Genet	More Carnivorous
Protein (%)	42.7	35.0	19.7-32.5
Fat (%)	23.9	52.0	9.0-30
Vitamin A (IU/g)	15.0	40.4	2.44-10
Vitamin D (IU/g)	2.2	0.71	0.25-1.0
Vitamin E (mg/kg)	174	281	27-120
Thiamin (mg/kg)	27.3	[2]	1.0-5.6
Riboflavin (mg/kg)	16.6	[2]	1.6-4.25
Pantothenic acid (mg/kg)	45.8	[2]	5.0-8.0
Niacin (mg/kg)	178	[2]	9.6-60
Pyridoxine (mg/kg)	20.7	[2]	1.6-4.0
Folacin (mg/kg)	2.4	[2]	0.2-1.3
Biotin (mg/kg)	0.96	[2]	0.07-0.12
Vitamin B_{12} (mg/kg)	0.24	0.07	0.02-0.035
Calcium (%)	1.4	1.75	0.29-1.0
Phosphorus (%)	1.1	0.84	0.26-0.8
Potassium (%)	0.69	0.67	0.4-0.6
Sodium (%)	0.37	0.32	0.05-0.4
Magnesium (%)	0.17	0.09	0.03-0.08
Iron (mg/kg)	278	381	80-114
Zinc (mg/kg)	203	103	50-94
Copper (mg/kg)	28.5	10.0	5.0-8.8
Iodine (mg/kg)	2.1	[2]	0.35-2.2
Selenium (mg/kg)	0.58	0.41	0.1-0.4

[1] Target nutrient levels listed in Table 6.
[2] Missing values in database so nutrients most likely meet targets.

Table 9: Diet provided to *ex situ* populations of Owston's civets at the Institution G (from Roberton et al. 2002)

Food	Item	Daily amount	Notes
Meat*	Pork	30g	Raw, minced
	Beef	30g	Raw, minced
	Chicken	30g	Raw, minced
Egg	Duck	1 per week	Raw/boiled & chopped
	Chicken	1 per week	Raw/boiled & chopped
Fruit	Apple	30g	Chopped
	Pear	30g	Chopped
	Papaya	30g	Chopped
	Custard apple	30g	Chopped
	Grape	30g	Whole
	Banana	1 medium size	Skinned & chopped
Vegetable**	Sweet potato	50g per week	Cooked/mashed, etc.
	Red sweet potato	50g per week	Cooked/mashed, etc.
	Sugar beet	50g per week	Cooked/mashed, etc.
Worms	-	150g	Live
Live food	Stick insects	Ad lib	Live
	Grasshoppers	Ad lib	Live
	Locusts	Ad lib	Live
	Crickets	Ad lib	Live
	Geckos	Ad lib	Live
	Centipedes	Ad lib	Live
	Tadpoles	Ad lib	Live
	Preying mantis	Ad lib	Live
	Small snails	Ad lib	Live
	Frogs	1 (week)	Live
	Small fish	2 (week)	Live
	Beetles	Ad lib	Live
	Moths	When available	Live

* Diet is fed in Viet Nam; all institutions should evaluate the risks of feeding raw meat.
** Fed in winter when insects are scarce.

General Feeding Information: Clean drinking water should always be available. Water can be provided in a bowl or water bottles, but care should be taken to ensure that every individual knows how to use a water bottle (spouts should be wedged open and gradually closed as all animals are observed using an automatic waterer of any type). Food should be offered in multiple non-tippable containers. These can be made from any material and can be disguised as necessary; however, bowls should be monitored for chewing by the animals. Whenever possible, enrichment food items and the regular diet should be scattered to encourage foraging (M. Dulaney, personal communication**).**

Water and food should be offered in multiple locations to prevent more dominant animals from monopolizing these resources in group housing situations; they should also be offered at varying heights to accommodate strata. Water and feeding stations should be located off the ground, in the branches or trees, for arboreal species (e.g., binturong, genet), and on or near the ground for terrestrial ones (e.g., banded linsang, Owston's civet, genet). There should be multiple food and water stations for groups of animals (e.g., binturong).

Binturong: Many binturongs do not adapt well to water bottles, and so watering systems of this type should be monitored closely to ensure all individuals are using them (M. Stinner, personal communication).

Owston's civet: In zoos and aquariums, the Owston's civets have shown a tendency to defecate in water. Therefore, it is recommended that at least two water bowls be provided in the exhibit; one of these can be sunk into the ground to encourage its use as a latrine. The animals will distinguish between the two and only use one as a toilet (Roberton et al. 2002).

Provision of Diet: 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 (M. Dulaney, personal communication). Some species/individuals

benefit from more frequent feedings, with the added bonus that this also can raise the activity level in an exhibit. An effective method is to provide the primary diet in one or two feedings, and schedule enrichment foods that can be scattered to encourage foraging/hunting during public hours. All food enrichment should be accounted for in the individual animal's daily caloric intake.

Binturong: In general, binturongs do not respond well when their primary diet is hidden, but will forage for highly desirable treats (M. Stinner, personal communication). Sweet, aromatic foods such as mashed bananas are also useful for hiding oral medications. Mashed bananas, in particular, can be mixed with kibbles to encourage their consumption by animals that tend not to consume these dry foods. Binturong groups generally show little aggression over food, but may become competitive for the last piece of a favored food item (C. Schultz, personal communication). As stated previously, the bulk of binturong diet should be fed at feeding stations, and highly preferred items only used for scatter feeds (M. Stinner, personal communication).

Linsang: Banded linsang should be fed a commercially available, nutritionally complete meat mix, as well as fruit, vegetables, whole animals, eggs, and occasional insects (K. Gilchrist, personal communication).

Owston's civet: Owston's civets should be fed on the ground (Roberton et al. 2002), and at least twice in 24 hours, preferably three times. Due to their nocturnal nature, feedings should actually take place at "dusk" within the exhibit, and again one to two hours later. Food should be scattered or hidden to promote activity, as this encourages activity and limits their tendency to develop stereotypies (Roberton et al. 2002).

Promoting Species-specific Behaviors: Whole prey (e.g., mice), insects, and favorite fruit/forage items can be placed around the exhibit to encourage movement and exploration; this is important for animals of all ages but can be particularly useful in encouraging movement of older animals. Foods can be hidden in locations that fit with the animal's natural feeding style (i.e., ground feeders vs. arboreal feeders). It is recommended that the diet be offered in several feeds over the course of the day. 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. Easily contaminated foods (mashed fruit, banana, prepared meat mixtures or similar) should be offered for short periods of time only (removed quickly if not consumed) and the entire diet should be offered in containers that are cleaned and sanitized after each use.

The provision of species appropriate enrichment items, including food, is advisable. The nutrient content of food items used for enrichment should be accounted for within the overall diet, varied in terms of content when it is offered, and presented in such a way as to encourage species-appropriate foraging activities (e.g., on the ground, in the trees, hidden in holes, etc.). Live insects, fruit pieces, kibble, frozen mice are just some of the food items that can be used.

Binturong: Binturongs have been observed diving and swimming to catch fish, and so the placement of some of their enrichment diet at the bottom of a pool may stimulate this activity (Nowak 1999; C.Schultz, personal communication). They also will eat frozen-thawed pinkies, which can be used as special treats. Binturongs have been reported to adjust well to cooked meat, eliminating health concerns associated with feeding raw meat (C. Schultz, personal communication). Selection of a dry kibble should be made based on the nutrient content of the diet, ability to maintain weight and condition of the animal, and other criteria as assigned by animal managers (maintenance of coat condition, etc).

Genet: Genets will eagerly forage for scattered items, especially mealworms, pinkie rats, and live crickets (M. Stinner, personal communication). These species will benefit from receiving whole prey such as rodents and chickens. These species are excellent foragers and should be provided the opportunity to do so as often as possible. Genets also will forage for a wide variety of fruits and vegetables (M. Stinner, personal communication).

Linsang: If animals are slow to adjust to their diet at a new facility, mixing in ground meat may help them to adjust (M. Dulaney, personal communication). Situations of this type should be closely monitored to ensure the animal is receiving a nutritionally complete diet.

Owston's civet: Owston's civet are believed to spend a great deal of time foraging in the substrate looking for insects, etc.; this species will benefit from the provision of live insects (e.g., crickets, worms, etc.) and other food items scattered throughout their enclosure on a regular basis (Roberton et al. 2002). As much

as possible, a variety of live insects should be incorporated into the diet, as Owston's civets are known to require constant stimulation to prevent stereotypies from developing. They often eat the leaves of bamboo, grasses, and wild ginger planted in their enclosures. Enclosures should be planted with bamboo, grasses, or plants with similar leaf structure, or these browse items should be supplemented in the diet. Some researchers have speculated that the consumption of this plant matter is required to assist in the passage of dirt consumed while eating worms, and as an intestinal scourer (Roberton et al. 2002).

Special Diets: 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 adults, reproducing animals (gestation and lactation), as well as needs for growing animals. The sample diets included herein have supported all life stages. 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 remains 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. Feeding should be observed to ensure the subordinate animals in group feeding situations receive the correct proportions of ingredients. When feeding groups of animals, 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, are often necessary to ensure adequate nutritionally complete feed consumption. Foods should be hidden in locations that identify with the animals' natural foraging behavior.

Dietary items offered, how they are offered, when they are offered, and how often they are offered should be age appropriate, e.g. young animals may require feeding more often, older individuals may require chopping of food, softer items, etc.

Owston's civet: For this species, from the time young are weaned until about eight months of age, their food can be chopped smaller than the adults' food, thus allowing them to chew the food more easily (Roberton et al. 2002).

Linsang: Offering vertebrate prey to linsang females with kits has been suggested to be helpful in preventing cannibalism of the kits (M. Dulaney, personal communication).

Reproductive Status: Diet increases may be necessary during lactation to keep females at a good weight level (M. Dulaney, personal communication) but, as with all diet adjustments, should be based on the objectively assessed weight/condition of the animal in question.. The increased amount should be based on the maintenance amount fed and the animal's weight/condition; increases should be designed to maintain the animal's desired weight as set by management.

Seasonal Changes in Temperature, Body Condition, Nutritional Requirements, and/or Activity Level: Not much is currently understood about the impact of seasonal changes on viverrid species; this is an area requiring further research. Members of the family Viverridae have been noted to easily gain weight in zoos and aquariums; this can be managed by closely and regularly monitoring their weight and adjusting diets as needed (Denver 2003).

Binturong: For binturongs, the amounts and frequency of feedings can be increased during cold months (C. Schultz, personal communication) based on the objectively assessed weight/condition of the animal in question; it is suggested that this species appears to voluntarily increase consumption during cold winter months (A. Moresco personal communication). Any diet increase should be based on the maintenance amount fed and the animal's weight/condition; increases should be designed to maintain the animal's desired weight as set by management.

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 energy and nutrients meeting the target nutrient values described herein. Conditions caused by nutritional deficiencies should be addressed promptly.

5.3 Nutritional Evaluations

As has been indicated through this chapter, an animal's weight should be objectively monitored on a regular basis, and the diet adjusted to maintain the individual at its optimum overall or seasonal target

weight. An individual's body size (structural) should be taken into consideration when formulating a diet instead of using generic male, female, or life stage diets. Some individuals have a tendency towards obesity and seasonal activity patterns may compound the problem. For these reasons, "goal weights" for individuals should be established. Body weight should be checked frequently so that diet adjustments can be made in a timely fashion to avoid over- or under-conditioned animals.

The diet should be evaluated (nutrient content determined and compared to target nutrient values listed herein) any time that a composition change is made (i.e. not a percentage increase or decrease across the entire diet, but when ingredients are increased or decreased without simultaneous and similarly proportionate increases and decreases of all items).

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. Hand-rearing may be necessary for a variety of reasons: rejection by the parents, ill health of the mother, or weakness of the offspring. 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 (e.g., aggression towards humans, inappropriate species-specific behavior, etc.) should be carefully weighed, 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 sooner rather than later. 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, possibly calling continuously, or conversely they may be hyperthermic 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). See Appendix I for a neonatal examination and monitoring protocol (Read & Meier 1996).

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 develop and interact with (Muir 2003).

Physical Care: Incubators are the best source of warmth for hand-reared viverrids. Heat lamps are too intense and can be dehydrating, hot water bottles can be used if necessary, and hypothermic kits can be warmed slowly by placing them next to a warm body (Muir 2003).

Small kits should be kept at a temperature between 26.5-29ºC (80-85ºF); 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 of 50% humidity as the desired incubator setting for viverrids. Meier (1986) suggests 29.4-32°C (85-90°F) and 50-60% humidity. The temperature should be gradually reduced to room temperature (roughly 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 kits will feel more secure if wrapped in layers of towels; this also aids in keeping them warm (Muir 2003).

Feeding: Some experienced hand-rearers recommend using formulas based on goat's milk (see binturong formula below) because small carnivores cannot absorb the fat globules in cow's milk; others prefer using feline or canine milk replacers – both of which have been used successfully in small carnivores (Muir 2003).

Kits should first be fed every two hours. The kit should be fed only if it is hungry and suckling vigorously, encouraging it to keep taking more milk will be fatal. Kits will not die of being slightly underfed, but overfeeding will kill them. As the volume of the feeds increases, the frequency can be reduced; every three hours during the second week, every four hours during the third week, etc. Kits will be hungry at some feeds, less at others, but this is quite normal (Muir 2003).

After the first week, it is not necessary to feed throughout the night and feedings between 6:00am and 12:00am should be sufficient. By 5-6 weeks of age, solids should be introduced, such as a finely ground, commercially available, nutritionally complete, meat mix with the formula or something similar depending on the species (chicken has tended to cause diarrhea in some small carnivore species). Solid foods can be offered on the handler's fingers to encourage them to eat (Muir 2003). Some experienced handlers recommend that milk be offered in a bowl, as long as the animal will take it, as this will help in building up their calcium; it is important though that the animal is eating its adult diet as well (Muir 2003).

Aspirated formula is frequently a contributing factor to neonatal respiratory infections, and care should be taken to select the appropriate nipple. "Neonates are obligate nose breathers. They cannot breathe through their mouths and nurse at the same time." "Respiratory infections cause a great deal of trouble because they not only interfere with breathing but they also make nursing difficult or impossible" (Meier

1985). The nipple's hole needs to suit the neonate's sucking reflex. Also, if a nipple is too stiff, the pup may tire and refuse to nurse.

When feeding kits, they should be held in the correct nursing position; ventrally or sternally recumbent, with the head up. The hand holding the bottle should be placed in such a way that it provides a surface for the pup to push against with its front feet. If milk comes through the nose of the kit, the nipple hole may be too large, or the pup may be trying to eat too quickly.

If a kit aspirates fluids, the recommended protocol is to hold it 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 a large amount of fluid is aspirated, or if fluid is heard in the lungs, Lasix™ (Furosemide) may be given, under the supervision of a veterinarian (K. Grant, personal communication). If an animal is placed on antibiotics, they should be given Benebac® before diarrhea begins (yogurt also can be helpful) (A. Moresco, personal experience). In these cases, a veterinarian should always be contacted first.

Only enough formula that will be used within a 24-hour period should be made at one time and any formula left after this period should be discarded. Formula should be strictly refrigerated, and any formula in bottles should not be warmed more than twice. Milk is an excellent medium for growing bacteria and so sanitation is vital. Bottles should be washed with hot water and a bottlebrush (soap left in the bottles can cause diarrhea and death), and then boiled for several minutes. The bottles should be cleaned well after every feeding, and boiled at least after every second feeding.

Hand-reared animals should be stimulated to urinate and defecate at least 4-5 times each day, generally before feeding. The genitals and anal area should be rubbed gently with a finger or towel to stimulate the baby to urinate and have a bowel movement. Species will differ in how often they defecate. Civets/binturong should have a generally solid stool, although a bit of runniness at the end is not a matter to worry over. The color of a civet/binturong stool will vary based on the fruit mixed into its formula.

If there appears to be a dietary problem, only one component should be changed at a time. "If several items are changed simultaneously, it is difficult to analyze problems. The formula itself may not be creating the illness; formula concentration, feeding frequency, gastric overload, and rapid changes can also produce gastrointestinal signs. Over feeding and extremely rapid feedings should be avoided" (Meier 1985).

It is important to monitor any diarrhea very carefully, as this can be a sign of bacterial overgrowth (e.g., *E. coli* or even *Salmonella*) or disbiosis. Yogurt may help prevent or alleviate this; Benebac® also may be helpful. Protracted diarrhea carries the risk of dehydration, as well as other more severe conditions, such as intussusceptions.

If an animal becomes constipated, often just adding a little bit more goat's milk to a civet/binturong formula will solve the problem. If a calcium supplement has been added to the formula, this should be stopped or the amount used significantly reduced. Any changes to the diet should be made slowly to avoid causing diarrhea. Be aware that the kits may become sore from repeated unsuccessful attempts to stimulate defecation. Using Vaseline® or another lubricant may lessen any soreness. In the event a formula adjustment does not work, a warm water enema often does; however, a veterinarian should be consulted before this is tried. If a kit goes for more than 36 hours without a bowel movement, there is probably a blockage of some sort, and veterinary attention should be sought. If at any time before this the animal becomes listless or will not eat, veterinary attention should be sought immediately.

Binturong: Binturongs requiring hand-rearing have been raised successfully using the formula below. The formula should be blended well and shaken or re-blended before each feeding (sometimes the banana can clog the nipple). Mixed formula should be refrigerated and replaced after 24 hours. Binturongs will eat between 2-4 ounces per feeding, four times a day. There is no information available on successful cross-fostering of binturong or any of the viverrid species (C. Schultz & M. Stinner, personal communication). From the age of about 5 weeks young binturong can be weaned onto a slurry of natural or organic peanut butter, bananas, yogurt, and vitamins (M. Stinner, personal communication). Cooked meat, or baby food meats without onions or other additives can be introduced at 6+ weeks, gradually introducing them to sliced/ground chicken, pinkies, and commercially prepared meat mix (M. Stinner, personal experience).

Table 10: Carnivore Preservation Trust formula for civets & binturong (M.Stinner)

Ingredients	Amount
Boiled water (allow to cool before adding to formula)	2½ C
Canned or fresh goat's milk	¼ C
Goat-A-Lac	¼ C
Banana, mashed	1
Pediatric vitamins	3-6 drops
Taurine	1 pinch
Yogurt	1 tablespoon
Fatty-acid coat supplement (Diet Derm® or similar)	-

Other viverrid species: There has not been much experience in hand-raising, nor are there records of cross-fostering, the other viverrids. More information is required.

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 the solitary species, contraception is not a large issue, as animals are typically housed as singletons. The AZA SCTAG Chair and the AZA Wildlife Contraception Center (www.stlzoo.org/contraception) should always be contacted for current contraception recommendations. The contraceptive methods currently (2010) most suitable for viverrids are outlined below. More details on contraception recommendations, products, application, and ordering information, can be found on the AZA Wildlife Contraception Center (WCC) website: www.stlzoo.org/contraception.

The progestin-based melengestrol acetate (MGA) implant, previously the most widely used contraceptive in zoos, has been associated with mammary pathology in felids and uterine pathology in felids and canids (Munson 2006, Moresco 2009). 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 but has not been tested in viverrids at this time.

Gonadotropin Releasing Hormone (GnRH) Agonists: GnRH agonists (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 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 viverrids has been conducted.

A drawback of these products is that time of reversal cannot be controlled. Neither the implant (Suprelorin®) nor the depot vehicle (Lupron®) can be removed to shorten the duration of efficacy to time reversals. The most widely used formulations are designed to be effective either 6 or 12 months, but those are for the most part minimum durations, which can be longer in some individuals.

Although GnRH agonists can also be an effective contraceptive in males, they are more commonly used in females. Monitoring efficacy by suppression of estrous behavior or cyclic gonadal steroids in feces is usually easier than ensuring continued absence of sperm in males, since most institutions cannot perform regular semen collections. Suprelorin® has been tested primarily in domestic dogs, whereas Lupron Depot® has been used primarily in humans, but should be as effective as Suprelorin® since the GnRH molecule is identical in all mammalian species.

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Appendix G: Description of Nutrients

Description of Nutrients (US 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 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 J: Selected Viverridae Reproduction and Development Parameters*

* From: Denver 2003; J.Reed-Smith, personal experience; Robertson et al. 2002; F.Kohn, personal communication; M.Stinner, personal experience

	Binturong *(Arctictis binturong)*	**Owston's civet** *(Chrotogale owstoni)*	**Banded linsang** *(Prionodon linsang)*	**Genet** *(Genetta genetta)*
Breeding season	Nonseasonal (indoors); Feb/Mar, May/June, Aug/Sep (outdoors)	Jan–Apr peak, possibly year-around	Nonseasonal	Nonseasonal
Estrus frequency	Polyestrous	Polyestrous; one litter per year		Polyestrous; 2 litters per year
Estrus duration	9-14 days	---	~11 days	---
Courtship	Female secretes attractive scent; becomes affectionate. Male marks & may become aggressive	Vulva swells & secretes, female scent marks more; mutual following and flank rubbing	---	Male sniffs & follows female, mutual rubbing
Copulation	Quiet/low purring, & multiple positions	May have polygynous mating system. Copulation lasts 2-3 minutes.	---	Lasts 3-5 minutes
Gestation (days)	84-99 90(Ismail et al. Undated)	75-90; shorter gestations have led to under-developed kittens	---	56-77
Number of offspring	1-6, av. 2	1-3	2-3	1-4, av. 2-3
Birth weight	319g (11.3 oz)	75-135g (2.7-4.8 oz)	~40g (1.4 oz)	61-82g (2.2-2.9 oz)
Eyes open	~2 weeks	4-15 days	---	5-12 days
First solid food	6-8 weeks	~8-10 weeks	---	1½ months
Weaned (weeks)	~6-8	12-18	---	8-18; catch own prey by 11-18 weeks
Sexual maturity (months)**	Males: 27.7 (8 has been reported) Females: 30.4	12-18	---	48

** Capable of breeding but may not be successful until older

Appendix L: AAZK Enrichment Committee, Enrichment Caution List (2007)

Dietary Enrichment

- Food enrichment, if uncontrolled, can lead to obesity and 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.
- If used, destructible items such as cardboard boxes and paper bags should be free of staples, tape, wax, strings or plastic liners.

Appendix N: Some Facts about the Binturong

AnAge (The Animal Ageing and Longevity Database (genomics.senescence.info/species/)

Adult weight : 12.25 kg (26.95 lb)
Maximum longevity : 27 years (Weigl 2005)
Female maturity: 925 days
Male maturity: 840 days
Gestation: 92 days
Weaning: 79 days
Litter size: 2
Litters per year: 2
Interval between litters: 348 days
Weight at birth : 0.318 kg (0.6996 lb)
Weight at weaning: 2.1 kg (4.62 lb)
Basal metabolic rate: 12.7470W
Body mass: 14.28 kg (31.416 lb)
BMR per body mass: 0.000893 W/g
Temperature: 36.7°C (98.1°F)