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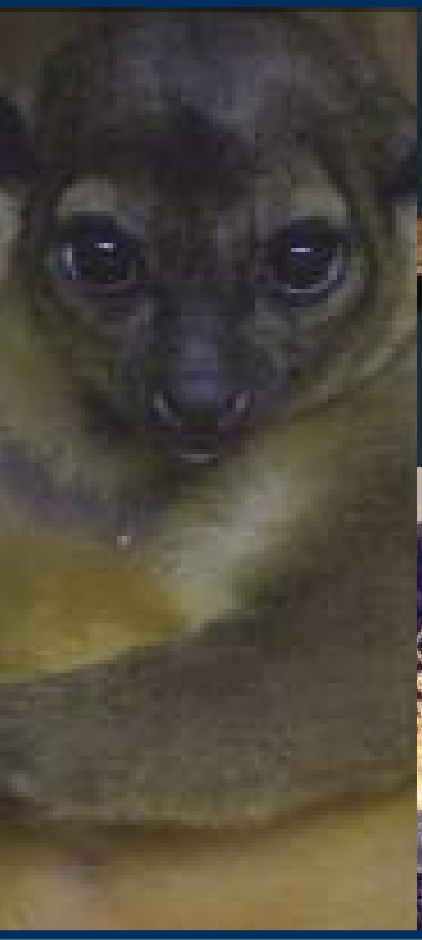

PROCYONID
(*Procyonidae*)
CARE MANUAL

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

Procyonid (Procyonidae) 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

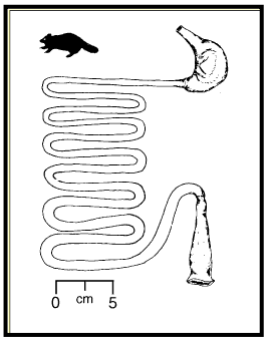
5.1 Nutritional Requirements

> **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 behavioral and nutritional needs of all procyonids (AZA Accreditation Standard 2.6.2). Diets should be developed using the recommendations of nutritionists, the Nutrition Advisory Group's feeding guidelines (www.nagonline.net/feeding_guidelines.htm), and veterinarians, as well as AZA Taxon Advisory Groups and Species Survival Plan® 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.

As a group, procyonids exhibit diverse natural feeding strategies and foraging behaviors. Although classified as carnivores, most procyonids are omnivorous, but the range of foods eaten and the means of procurement differ considerably among genera. Raccoons forage for invertebrates, small vertebrates, and fruits along bodies of water (Poglayen-Neuwall 1990; Nowak 1999). Ringtails and cacomistles feed primarily on small vertebrates, insects, and fruit (Poglayen-Neuwall 1990; Nowak 1999). Kinkajous are largely arboreal, mainly frugivorous, and have been observed to consume fruit pulp and seeds, flowers, honey, young leaves and buds, and small invertebrates and vertebrates (Ford & Hoffman 1988; Poglayen-Neuwall 1990; Denver 2003). Coatis forage for invertebrates, small vertebrates, and fruits on the forest floor and in trees (Poglayen-Neuwall 1990; Nowak 1999).

Digestive System Morphology and Physiology: Morphological and behavioral adaptations for foraging are diverse across procyonids. Kinkajous have a long, protrusable tongue, presumably for obtaining food from crevices, and prehensile tails which permit terminal branch feeding. Raccoons have highly prehensile forepaws, which they use to search for, manipulate, and capture prey that cannot be readily seen underwater. In general, the stomach of procyonids is simple (note figure to left, raccoon gastrointestinal tract; Steven and Hume 1995) and the distal segment of the stomach is marked only by a sudden change in mucosa. The intestine of the raccoon is longer than that of the dog or cat (2.7 times body length), and the hindgut is shorter, with neither a cecum nor a distinct ileocolonic valve (Stevens and Hume 1995). No grossly visible specialization for frugivory has been noted in kinkajous (Wright and Edwards 2009).



Steven and Hume 1995

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. 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."

Procyonids have lower than predicted metabolic rates as compared to the Kleiber curve, suggesting that relative energy requirements are lower than those of felids, canids, and mustelids of comparable size (McNab 1989). This has been attributed in part to reduced muscle mass of some of the arboreally adapted species in the group. Basal metabolic rates are not species constant and will be higher (as much as twice) for growing individuals compared to adults (Robbins 1993). See Table 6 for the Basal Metabolic Rate for selected procyonid species. Paradoxically, despite a depressed metabolic rate, some species (e.g., kinkajou, ringtail, and cacomistle) have limited ability to dissipate heat and may become hyperthermic at even moderately high ambient temperatures (>33 °C/91 °F). Observations of kinkajous indicate that they need approximately 50 kcals/d less than an equivalently sized mammal along the mouse-elephant (placental mammal) body curve because its BMR is 30-34% lower (Wright and Edwards 2009). Thus, a diet formulated for kinkajous based on a metabolic rate formula for other similarly sized mammals can provide too much food and increase risk for obesity.

Table 6: Basal Metabolic Rate (BMR) of selected procyonid species (from: Muñoz-Garcia & Williams 2005, citing original sources)

Species	**Body Mass (g)**	**BMR (kJ/d)**	**Diet (%) (meat/invert/veg)**	**Home range (km^2)** (females only)
Nasua nasua	3,850 ± 212	486.02 ± 38	2/58/41	Not listed
Nasua narica	3,630 ± 548	573.25 ± 77	Not listed	Not listed
Bassariscus astutus	860.7	185.5	Not listed	1.85
B. sumichrasti	1,287.3 ± 133	305.24 ± 25	Not listed	Not listed
Potos flavus	2,688	447.71	0/21/78	0.2
Procyon lotor	4,847	742.23	0/73.5/26.5	1.22
P. cancrivorus	1,160	221.75	13.5/20.5/65.5	Not listed

Nutrient Requirements: Although we know many of the items consumed by procyonids, the nutrient content of these items has not been completely characterized. Beyond this, diversity within the family's feeding ecology precludes species or even genera-specific target nutrient levels. In the case of procyonids, target nutrient levels are based on those of well-studied omnivores. 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 individuals (see Table 7). These ranges are provided in comparison to straight dog (NRC 1974; AAFCO 1999), Arctic fox (NRC 1982) and Mink (NRC, 1982). As additional information becomes available, these ranges should be adjusted to reflect new knowledge.

Table 7. Target nutrient ranges for baseline species (dry matter basis).

Nutrient	More Omnivorous[1] Kinkajou (*potos flavus*), Ringtail (*bassariscus astutus*), Coati (*nasua narica*), Raccoon (*procyon lotor*)
Protein (%)	17.5-26.0[1a]
Fat (%)	5-8.5
Linoleic Acid (%)	1.0-1.3
Vitamin A (IU/g)	0.5-5.9
Vitamin D (IU/g)	0.5-0.55
Vitamin E (mg/kg)	27-50
Thiamin (mg/kg)	1.0-2.25
Riboflavin (mg/kg)	1.6-10.5
Pantothenic acid (mg/kg)	7.4-15.0
Niacin (mg/kg)	11.4-20.0
Pyridoxine (mg/kg)	1.0-1.8
Folacin (mg/kg)	0.18-0.5
Biotin (mg/kg)	0.1-0.12
Vitamin B_{12} (mg/kg)	0.022-0.035
Calcium (%)	0.3-1.2[1b]
Phosphorus (%)	0.3-1.0[1b]
Potassium (%)	0.4-0.6
Sodium (%)	0.04-0.3
Magnesium (%)	0.04-0.06
Iron (mg/kg)	30-90
Zinc (mg/kg)	50-120
Copper (mg/kg)	6.0-12.4
Iodine (mg/kg)	0.9-1.54
Selenium (mg/kg)	0.1-0.35

[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.

Several factors affect nutrient requirements. These factors include: age, physiological state, health status, environment, activity, and group dynamics. The target nutrient values in these standard recommendations encompass the needs for maintenance of adults and reproducing animals (gestation and lactation), as well as the needs of growing animals. The sample diets included in section 5.2 have supported all life stages.

Seasonal changes in nutritional requirements: Development of individual standard and predictable feeding behavior patterns based on seasons can serve as effective diet management tools.
Coatis: Male coatis appear particularly prone to weight gain in the fall; while this gain may be temporary, due to their tendency to have a reduced appetite during the winter months, care should be taken to make sure they do not become too obese during this period; weight gained in the fall is often naturally dropped in the spring (Standley 1992).

Raccoons: Raccoons may lose as much as 30-50% of their peak autumn body weight during the winter dormant period. Thus, the normal weight dynamic patterns of raccoons over parts of their range may be considerably more variable than those for subtropical or tropical species or other procyonid genera (Roberts 1997). Raccoons are somewhat unusual among the procyonids in that they undergo variable periods of dormancy during the winter over much of their range (from central United States to Canada). Interestingly, it is the appearance of a permanent snow cover, rather than low temperatures per se, which appears to initiate the onset of dormancy in free-ranging raccoons. This suggests that the (lack of)

availability of resources may play a role in triggering this phenomenon. Dormancy should not be confused with hibernation or torpor, as dormant raccoons are easily aroused. However, activity and food consumption drop dramatically during exposure to prolonged low temperatures, and animals rely on accumulated fat stores to meet energy requirements.

5.2 Diets

The formulation, preparation, and delivery of all diets must be of a quality and quantity suitable to meet the animal's nutritional, 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.

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.

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

(2.6.3) 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.

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.

Sample Diets: There is a wide range of diets that can be appropriate for procyonids. As omnivores, diets that contain a variety of food items and food groups appear most appropriate, with emphasis added toward the vertebrate and invertebrate portions of the diet for more carnivorous members of the group (raccoon, coati, ringtail and cacomistle) and fruits for the more frugivorous members (kinkajou). It should be noted that the nutrient content of all items consumed (whole prey, nutritionally complete foods, produce, etc) should be known and included in the nutrient analysis of the diet. This will help to develop and maintain a diet which meets both the nutritional needs of the species and also avoid incidence of metabolic problems (metabolic bone disease, obesity, anorexia, etc).

In this case, sample diets are provided as examples only. The goal is to provide a diet that meets target nutrient values and is readily consumed. Ideally, a palatable nutritionally complete food item should be used as the base of the diet, to which vertebrate and invertebrate prey, and produce may be added as appropriate based on feeding strategy. Offering hard food items (bones, biscuits, etc) will encourage natural tooth abrasion and promote dental health. Although the North American raccoon is not managed within the AZA SCTAG, two diets are provided for additional reference in Table 8.

Table 8. Sample diets from AZA institutions of procyonid species as fed daily*

Species	Common Name	Institution	Food Item[1]	grams/day	% in diet
Potos flavus	Kinkajou	Institution B	Seasonal fruit – used apple	115	43.00
			Insectivore- Reliable Protein Prod	60	22.43
			ZuPreem Feline canned	60	22.43
			Nectar Mix[2]	30	11.22
			Purina Labdiet 5045 High Protein	2	0.75
			Crickets	0.4	0.15
			Mealworms	0.07	0.03
			Total	267.47	100
		Institution C	Mazuri Omnivore Biscuit	86	33.34
			Vegetable – used carrot	86	33.33
			Fruit – used apple	86	33.33
			Total	258	100
		Institution D	Corn on the cob	50	13.24
			Apple	50	13.24
			Hill's Science Canine Light dry	50	13.24
			Hill's Science Original Adult dry	50	13.24
			IAMS Adult Chicken Entrée can	28	7.41
			Mazuri Browse Biscuit	12	3.18
			Night crawlers (4g Sun)	0.57	0.15
			Cantaloupe (50 g T/Th)	14.2	3.78
			Kiwi (50 g W)	7.1	1.89
			Papaya (50 g Th)	7.1	1.89
			Mealworms (0.1 g W)	0.01	0.004
			Grapes	50	13.24
			Banana (40 g M,W,F)	17.1	4.54
			Fig (40 g M,Th,F)	17.1	4.54
			Egg, hard-boiled (40 g M,T,W,F)	22.8	6.05
			DAK primate Gel (10g Sun)	1.4	0.38
			Total	377.7	100
Bassariscus astutus	Ringtail/Cacomistle	Institution B	Nebraska Special Beef Feline	35	22.22
			Chicks (30 g M,W,F)	12.8	8.16
			Mouse (30 g Su,T,Th,Sa)	17.1	10.88
			Fruit – used apple	35	22.22
			Insectivore– Reliable Protein Prod	35	22.22
			Egg, Hard-boiled	22.5	14.29
			Total	157.4	100
		Institution E	Natural Balance Carnivore 5%	24	37.33
			Premium Edge Chicken/Rice Dog	11.1	17.33
			Egg, hard-boiled	3.4	5.33
			Fruit used apple	7.7	12.0
			Vegetable used carrot	7.7	12.0
			Mealworms	1.7	2.67
			Crickets	0.57	0.89
			Mouse (56 g Th- only mouse fed)	8	12.44
			Total	64.17	100
		Institution C	Fruit Mix[3]	55	53.40
			Natural Balance Carnivore 10%	29	28.16
			ZuPreem Feline Canned	10	9.71
			Mouse	9	8.74
			Total	103	100
Nasua narica	Coati (white nosed)	Institution B	Fruit used apple	120	23.83
			Vegetable used carrot	120	23.83
			Nebraska Special Beef Feline	120	23.83
			ZuPreem Feline can	60	11.91
			Purina Labdiet 5045 high protein	60	11.91
			Egg, hard-boiled	19.3	3.83
			Cooked Roast Beef	4.3	0.85
			Total	503.6	100
		Institution E	Natural Balance Carnivore 5%	43	20.84

Species	Common Name	Institution	Food Item[1]	grams/day	% in diet
Potos flavus	Kinkajou	Institution B	Seasonal fruit – used apple	115	43.00
			Premium Edge Chicken/Rice Dog	60	29.09
			Lake Smelt	4.3	2.08
			Mealworms	8	3.88
			Crickets	8	3.88
			Egg, hard-boiled	28	13.57
			Apple	28	13.57
			Banana	27	13.09
			Total	206.3	100
		Institution C (brown nosed)	Mazuri Omnivore	103	41.56
			Egg, hard-boiled	33	13.32
			Banana	10.8	4.38
			Apple	20.0	8.07
			Grapes	6.4	2.59
			Orange	17.0	6.86
			Sweet potato cooked	9.3	3.75
			Mealworms	8.1	3.29
			Crickets	10.8	4.38
			Mice	29.2	11.8
			Total	247.8	100
Procyon lotor	Raccoon	Institution D	Hill's Science Original Adult dry	85.0	63.33
			Grapes	16.0	11.92
			Carrots	9.7	7.24
			Cantaloupe	0.85	0.64
			Apple	0.85	0.64
			Banana	0.43	0.32
			Super worms	0.85	0.64
			Cricket (3/4")	0.21	0.16
			Sweet Potato	6.0	4.47
			Apple Juice Concentrate	14.3	10.64
			Total	134.2	100
		Institution F	Apple	8	4.15
			Grape	9	4.66
			Carrot	16.5	8.55
			Sweet Potato	16.5	8.55
			Leafy Mix[4]	27	13.99
			Sports Mix Dog Food dry	58	30.05
			Purina Labdiet 5038 Monkey	58	30.05
			Total	193	100

[1] Reliable Protein Products, Phoenix, AZ 85050; Zupreem, Shawnee, KS 66214; PMI Nutrition International, Grays Summit, MO 63039; Hill's Pet Nutrition, Inc. Topeka, KS 66603; P&G Pet Care (IAMS), Cincinnati, OH 45220; Central Nebraska Packing, Inc. North Platte, NE 69103; Natural Balance Pet Foods, Inc. Pacoima, CA 91331; Premium Edge Brand® Meta, MO 65058; Midwestern Pet Foods, Inc. Evansville, IN 47725.

[2]Nectar mix from Omaha contains 9% raw egg, 5% Roudybush nectar 3 powder, 2% dry rice baby cereal, 4% honey, and 80% water.

[3]Fruit mix from Institution C 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.

[4]Institution F Leafy Mix is 45% iceberg lettuce, 11% kale, 22% spinach, and 22% celery shredded.

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

The following table (Table 9) provides a comparison of the sample diets listed in Table 8 to target nutrient levels identified in section 5.1.

Table 9. Nutrient content of sample diets[1] (dry matter basis)

Nutrient	Institution B Kinkajou	Institution C Kinkajou	Institution D Kinkajou	More Omnivorous
Protein (%)	28.2	21.9	21.3	17.5-26.0
Fat (%)	16.7	6.7	10.5	5-8.5
Vitamin A (IU/g)	9.2	92[2]	6.2	0.5-5.9
Vitamin D (IU/g)	0.45	3.1	0.27	0.5-0.55
Vitamin E (mg/kg)	56.9	70	183	27-50
Thiamin (mg/kg)	7.3	14.0	1.7	1.0-2.25
Riboflavin (mg/kg)	8.0	6.3	2.3	1.6-10.5
Pantothenic acid (mg/kg)	18.7	19.0	8.6	7.4-15.0
Niacin (mg/kg)	52.6	78.9	11.9	11.4-20.0
Pyridoxine (mg/kg)	3.4	9.7	2.9	1.0-1.8
Folacin (mg/kg)	0.95	2.3	1.2	0.18-0.5
Biotin (mg/kg)	0.26	0.16	0.03	0.1-0.12
Vitamin B_{12} (mg/kg)	0.03	0.04	0.01	0.022-0.035
Calcium (%)	0.38	2.0	0.54	0.3-1.2
Phosphorus (%)	0.31	1.4	0.46	0.3-1.0
Potassium (%)	0.36	1.1	0.72	0.4-0.6
Sodium (%)	0.12	0.30	0.21	0.04-0.3
Magnesium (%)	0.03	0.20	0.10	0.04-0.06
Iron (mg/kg)	118	481	36	30-90
Zinc (mg/kg)	66	157	15.3	50-120
Copper (mg/kg)	5.4	13.4	3.5	6.0-12.4
Iodine (mg/kg)	0.77	1.2	0.18	0.9-1.54
Selenium (mg/kg)	0.02	0.45	0.07	0.1-0.35

Nutrient	Institution B Ringtail	Institution E Ringtail	Institution C Ringtail	More Omnivorous
Protein (%)	38.4	40.8	33.2	17.5-26.0
Fat (%)	21.8	18.4	19.7	5-8.5
Vitamin A (IU/g)	9.0	95.6	61.9	0.5-5.9
Vitamin D (IU/g)	1.3	0.55	0.72	0.5-0.55
Vitamin E (mg/kg)	195	261	174	27-50
Thiamin (mg/kg)	29.9	5.2	8.1	1.0-2.25
Riboflavin (mg/kg)	9.2	8.9	12.0	1.6-10.5
Pantothenic acid (mg/kg)	13.9	21.3	24.6	7.4-15.0
Niacin (mg/kg)	35.2	96.4	84.2	11.4-20.0
Pyridoxine (mg/kg)	5.9	6.4	10.2	1.0-1.8
Folacin (mg/kg)	1.4	0.22	11.8	0.18-0.5
Biotin (mg/kg)	0.15	0.57	0.81	0.1-0.12
Vitamin B_{12} (mg/kg)	0.09	0.05	0.06	0.022-0.035
Calcium (%)	1.1	0.97	1.1	0.3-1.2
Phosphorus (%)	0.89	0.68	0.54	0.3-1.0
Potassium (%)	0.50	0.40	0.65	0.4-0.6
Sodium (%)	0.28	0.26	0.49	0.04-0.3
Magnesium (%)	0.07	0.19	0.18	0.04-0.06
Iron (mg/kg)	164	82.4	109	30-90
Zinc (mg/kg)	74.6	121	120	50-120
Copper (mg/kg)	10.5	9.2	11.8	6.0-12.4
Iodine (mg/kg)	0.69	0.40	0.68	0.9-1.54
Selenium (mg/kg)	0.29	0.43	0.12	0.1-0.35

Nutrient	Institution B Coati	Institution E Coati	Institution C Coati (brown-nosed)	More Omnivorous
Protein (%)	31.9	33.8	29.8	17.5-26.0
Fat (%)	20.2	17.6	13.4	5-8.5
Vitamin A (IU/g)	229[2]	4.4	28.7[2]	0.5-5.9

Nutrient	Institution B Kinkajou	Institution C Kinkajou	Institution D Kinkajou	More Omnivorous
Protein (%)	28.2	21.9	21.3	17.5-26.0
Vitamin D (IU/g)	2.8	0.26	3.0	0.5-0.55
Vitamin E (mg/kg)	175	244	70.3	27-50
Thiamin (mg/kg)	13.7	2.6	13.2	1.0-2.25
Riboflavin (mg/kg)	7.9	5.6	6.7	1.6-10.5
Pantothenic acid (mg/kg)	34.0	13.9	20.7	7.4-15.0
Niacin (mg/kg)	73.2	45.7	72.3	11.4-20.0
Pyridoxine (mg/kg)	8.4	4.8	7.8	1.0-1.8
Folacin (mg/kg)	4.2	0.25	2.2	0.18-0.5
Biotin (mg/kg)	0.20	0.27	0.16	0.1-0.12
Vitamin B_{12} (mg/kg)	0.05	0.03	0.04	0.022-0.035
Calcium (%)	1.0	0.36	1.9	0.3-1.2
Phosphorus (%)	0.82	0.32	1.4	0.3-1.0
Potassium (%)	1.0	0.37	0.94	0.4-0.6
Sodium (%)	0.35	0.17	0.32	0.04-0.3
Magnesium (%)	0.14	0.11	0.19	0.04-0.06
Iron (mg/kg)	218	31.7	471	30-90
Zinc (mg/kg)	115	124	162	50-120
Copper (mg/kg)	13.1	5.3	13.6	6.0-12.4
Iodine (mg/kg)	1.0	0.19	1.2	0.9-1.54
Selenium (mg/kg)	0.27	0.47	0.54	0.1-0.35

Nutrient	Institution F Raccoon	Institution D Raccoon	More Omnivorous
Protein (%)	19.3	22.1	17.5-26.0
Fat (%)	6.8	13.6	5-8.5
Vitamin A (IU/g)	95.7[2]	43.6[2]	0.5-5.9
Vitamin D (IU/g)	3.3	[3]	0.5-0.55
Vitamin E (mg/kg)	31.6	2.1[3]	27-50
Thiamin (mg/kg)	5.1	0.34[3]	1.0-2.25
Riboflavin (mg/kg)	4.8	0.42[3]	1.6-10.5
Pantothenic acid (mg/kg)	31.7	1.2[3]	7.4-15.0
Niacin (mg/kg)	64.1	2.6[3]	11.4-20.0
Pyridoxine (mg/kg)	7.4	0.77[3]	1.0-1.8
Folacin (mg/kg)	3.7	0.04[3]	0.18-0.5
Biotin (mg/kg)	0.05	[3]	0.1-0.12
Vitamin B_{12} (mg/kg)	0.01	0.03[3]	0.022-0.035
Calcium (%)	0.48	0.63	0.3-1.2
Phosphorus (%)	0.27	0.58	0.3-1.0
Potassium (%)	0.45	0.72	0.4-0.6
Sodium (%)	0.14	0.25	0.04-0.3
Magnesium (%)	0.08	0.12	0.04-0.06
Iron (mg/kg)	95.6	3.0[3]	30-90
Zinc (mg/kg)	58.7	1.1[3]	50-120
Copper (mg/kg)	7.2	0.47[3]	6.0-12.4
Iodine (mg/kg)	0.46	[3]	0.9-1.54
Selenium (mg/kg)	0.11	[3]	0.1-0.35

[1]Target nutrient levels listed in Table 7.
[2] High due to beta carotene from the carrots and sweet potato in diet.
[3]Missing most of the nutrient information on the Hills Science Diet Adult dry so nutrients most likely meet targets set.

Provision of Food and Water: Heavy water bowls made from metal, or a sturdy, non-chewable plastic can be used for water and food. Small pools with running water may also be used as watering points. All food and water containers should be cleaned and disinfected daily. Water containers used for ringtails and coatis should be heated in winter, otherwise their body temperatures may drop too low as they drink ice cold water. Ice-cold water also may prevent them from drinking an adequate amount of water (D.Bressler, personal communication). Water should always be available, but it is particularly important for ringtails if they are not provided with enough fruit (from which they naturally obtain water) in their diet (Reed-Smith et al. 2003).

In general, only foods that can easily be contaminated by dirt (e.g., moist foods or fruit) should be placed in containers, the rest should be scattered or hidden for the animals to find (K. Schilling, personal experience). This portion of the daily diet should be reserved for use as enrichment during the course of the exhibit day. Dry foods, or foods that can be left whole, should be scattered or hidden around the exhibit. Fruit can be placed on branches or skewered onto heavy bolts placed in branches. This will promote activity and provide the animals an opportunity to engage in natural foraging behaviors. The provision of decomposing logs that can be torn apart, or logs with holes for hiding insects, larvae, fruit, etc. also will encourage foraging behaviors.

Procyonids eat a wide variety of foods. Procyonids should be provided with food at least twice a day, preferably three, and it is recommended that the diet be provided in ways that promote species-appropriate foraging and feeding behaviors (e.g., hidden, scattered, hung, etc.), where appropriate. Given that coatis can spend 95% of their active time foraging in the wild (Kaufmann 1962), it is important that the frequency of food delivery, and the means of presenting the food to these animals, be closely based on the natural history of the species in order to promote species-appropriate foraging, and prevent the development of abnormal behaviors.

Ringtail and cacomistle: The AZA SCTAG recommends that a well-balanced diet includes a variety of items as noted in previous sections and that animals' weight and physical condition should be checked regularly. Carbohydrate consumption (including fruit and vegetable forms) should be monitored, particularly the amounts offered males, as ringtails and cacomistles are prone to obesity (D. Bressler, personal communication).

Coati: Coatis benefit from a scattered feeding approach, allowing them to exercise their natural foraging approach to feeding. All items can be scattered or hidden as long as keepers monitor that all individuals are feeding, and leftover food is cleaned up daily.

Kinkajou: The unfortunate title "honey bear" for kinkajou has often led to the erroneous assumption that this species requires honey or other sweets in its diet. Overindulgence in sweets can have disastrous dietary and medical consequences and should be avoided (Roberts 1997).

Species-appropriate Foraging and Feeding: Most procyonids are nocturnal or crepuscular, meaning active at or between dusk and dawn; the notable exception is the coati, which forages during the day (Denver 2003). While it is not possible to mimic the same diet (or environment) for *ex situ* populations of animals as their free-ranging conspecifics would utilize, it is recommended that the diet is offered during the period of the day when the animals would typically be expected to actively forage (AZA Small Carnivore TAG recommendation 2005). This will not only discourage pest species, but will encourage typical foraging behavior. Easily soiled food such as meat products should be offered in containers that are cleaned and sanitized after each use.

Procyonids have been observed to consume anything from soft fruits and berries to acorns and crayfish, and most have well developed canines and a strong dentition. Many are highly dexterous or have relatively well developed prehensile abilities, thus altering diet item size or form and scattering part of the diet can contribute to stimulating natural foraging behaviors, encourage problem solving, and in general provide variety in daily activity patterns.

Feeding soft foods only (such as canned dog food, cottage cheese, etc.) will promote dental tartar, which, if left untreated, can lead to gingivitis and eventual loss of teeth (Roberts 1997). However, soft foods should not be completely ruled out as occasional enriching treats (K.Schilling, personal experience).

5.3 Nutritional Evaluations

Group dynamics often play a role in the nutrient content of the diet consumed by individuals in the group. When housed in groups, procyonids should be observed to insure the subordinate animals consume the correct proportions of diet ingredients. Often increasing the number of feeding times per day, placing the food in several locations, distracting some of the animals to allow others adequate access to food, or separating animals when possible are necessary in a group of procyonids.

Diets should be formulated taking into account an animal's size, activity level, age, and over-all health. Target weights should be set for each animal and diets formulated to maintain that weight. Procyonids have been noted to become obese from overfeeding, lack of exercise, or a combination of the two. "Goal weights" for individuals should be established (ideally, general, and seasonal), and body

weight checked frequently, so that diet adjustments can be made in a timely fashion to avoid over or under-condition.

Ringtails and cacomistles have been noted to easily gain weight in zoos and aquariums. This can be managed by regularly monitoring their weight and adjusting diets as needed.

Health Status: 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 this should be managed on an individual basis to avoid obesity.

Analysis of weight fluctuations can be a valuable tool for managing individuals and populations. Weight changes can reflect nutritional problems (obesity and under-conditioning), illness (cancer, organ failure, etc.), other medical conditions (intestinal blockage, etc.), changes in reproductive condition (e.g., pregnancy or weight loss during lactation), and hormonally or environmentally induced changes in metabolism (e.g., prior to dormancy and the onset of the breeding season). Correlating weight changes with key life history parameters will enable animals to be managed much more effectively and efficiently.

See Table 13 for estrus, courtship, copulation, gestation, and kit development information.

7.4 Birthing Facilities

As parturition approaches, animal care staff should ensure that the mother is comfortable in the area where the birth will take place, and that this area is "baby-proofed." See below for summary information about birthing facilities, however Section 7.1 and 7.3 also should be consulted for management considerations.

Coati: Female coatis should be provided with their own nest box that should be approximately 61cm x 46cm x 61cm (2 ft long x 1.5 ft wide x 2 ft high) (Standley 1992, Campbell 2001), as well as an alternate nesting site where she can move her young if she becomes nervous (Standley 1992; V.Walkosak, unpublished information 2003). Female coatis should be separated from the group just prior to giving birth (V.Walkosak, unpublished information 2003). The female should be left alone without human interference, unless required, or the mother can become too stressed (Haas & Roback 2000).

The well-bedded nest boxes should be provided in quiet, private areas easily accessed by the keeper staff, once the female has settled down, for cleaning and monitoring of young development.

Kinkajou: No information is available on recommended nest box size for this species. The female should be provided with at least two nest box choices; boxes should be large enough for her to turn around in and to accommodate the presence of young. Boxes should be provided with dry nesting material. Females should not be disturbed immediately after parturition unless trouble is suspected. Normal routines should be maintained but noise kept to a minimum.

Ringtail and Cacomistle: There is a high rate of cannibalism of ringtail babies in *ex situ* populations, often as the result of improper husbandry. This is a highly sensitive species that should be given ample time (several weeks) to become accustomed to new surroundings before giving birth. Schilling recommends isolating female ringtails in familiar surroundings and that unfamiliar/loud noises should be kept to a minimum (K. Schilling, personal experience). Females should be given quiet and privacy as well as nest box choices. Females of both species should be separated from exhibit mates. Primiparous ringtail females should be monitored to ensure they are caring for their young and have not abandoned or eaten them.

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: 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 should be carefully weighed (aggression towards humans, inappropriate species-specific behavior, etc.), and plans made to minimize deleterious effects on the development of natural behaviors as far as possible. This may require extensive time commitment on the part of staff, plans for fostering, relocation of the young, exposure to species-specific sounds, etc. Once the decision has been made and the young have been abandoned by the mother, or are consistently getting weaker/losing weight, it is best to remove the infants as soon as possible.

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 hypothermic and scattered around the enclosure. Another indicator of trouble would be the female moving around the exhibit continuously while carrying the young; this could mean she is not comfortable with the denning provided, or there is something wrong with her or the young (Muir 2003).

If it is necessary to remove offspring because of an exceptionally large litter, it is best to remove two of the largest infants. 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 play with (Muir 2003).

Physical care: Incubators are the best source of warmth; heat lamps are too intense and can be dehydrating or cause serious burns. Hot water bottles can be used in a pinch and hypothermic babies can be warmed slowly by placing them next to your body (Muir 2003). Most babies will feel more secure if wrapped in layers of towels; this also aids in keeping them warm (Muir 2003). Ringtails and cacomistles should be placed in an incubator with a floor temperature of ~38ºC (100ºF) (Partridge 1992).

Feeding Protocols: Young mammals require a specific number of kcal/day for optimum development and growth. If the formula being offered is nutritionally dense, fewer feedings will be necessary than with formulas that are more dilute or low in fat or protein. Following is a method for calculating the volume of food to be offered daily, the volume that should be offered at each feeding and the number of feedings per day (adapted from Grant 2004).

The Basal Metabolic Rate (BMR) or Basal Energy Requirement (BER) is the amount of energy (kcal) an animal needs for basic metabolic function at rest in a thermoneutral zone. In other words, the amount of calories it needs to stay alive, without having to use energy to maintain normal body temperatures. The formula to determine the BER/BMR is: 70 x body wt (in kg.)$^{0.75}$ (Kleiber 1947). For a 30g infant the BER would be: 70 x 0.03$^{0.75}$ = 5.0 kcal/day. For a 90g infant the BER would be: 70 x 0.09$^{0.75}$ = 11.5 kcal/day. For this formula, 0.75 is an exponent that is multiplied by the body weight to put mammals of different sizes on the same playing field when assessing metabolism. As body weight increases, metabolism decreases, so a larger animal will not have the same caloric requirement as a much smaller animal (e.g., mice consume a much higher percentage of their body weight than an elephant does). In order to complete the calculations, you will need a scientific calculator that does exponents other than squares. Follow steps 1-3 below to calculate the BER. Add step 4 if you want to calculate the Maintenance Energy Requirement. Table 14 provides some pre-calculated MER values.

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

Once the BER is established, the Maintenance Energy Requirement (MER) can be calculated. This measurement determines the amount of calories the animal needs to function in a normal capacity at its life stage. For adults in a maintenance life stage, the BER is multiplied by 2. For infants that have a higher metabolism and are developing and growing, the BER is multiplied by 3 or 4 (Evans 1987), depending on the species and other factors.

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

The following calculations will determine the total volume and kcal to feed/day, as well as the amount of formula for each feeding and the total number of feedings daily (see Table 14 for sample calculated kcal/day and stomach capacity for various body weights).

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

Table 14: Chart for determining kcal/day and stomach capacity for various body weights (Grant 2004)

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

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

The stomach capacity of most eutherian mammals is 5% body weight (bw). This is the volume of formula that should be offered at each feeding (Grant 2004). The total volume offered per day will depend

on how nutrient dense the formula is. The optimal amount would be the number of kcal calculated from the infant's body weight (see Table 14).

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

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

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

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

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

Digestive upset is a common issue with hand-reared neonates, and may be associated with several factors (Meier 1985): a) inappropriate milk formula, b) feeding frequency, c) overfilling the stomach, d) rapid changes in the diet, and e) improper storage of formula (spoilage). Unused formula requires refrigeration, and is safe to use for 24-36 hours after preparation and refrigeration. Refer to the label guidelines of the formula manufacturer. When digestive upset, characterized by diarrhea, bloating, inappetance, and/or extreme fuzziness occurs, it is recommended that one factor is analyzed and/or changed at a time. Lactose intolerance also should be considered, particularly for the coati (D.Bressler, personal communication).

Ringtail and cacomistle: The formula of choice is Esbilac® (Pet Ag® manufacture KMR®, Esbilac®, Multi-Milk® and the Zoologic Milk Matrix® line; contact details: 261 Keyes Ave., Hampshire, IL. 60140, 1-800-323-0877/ 1-800-323-6878 www.petag.com), which should be offered 9 times per day for the first 14 days. Total intake per day should be about 6ml per 24 hours for this period. On days 15-30, 18ml should be offered, daily, in 7 feedings (Partridge 1992). Total food amounts should be based on the infant's weight. KMR® should not be used for ringtail; they appear to respond initially but then can go downhill quickly, often dying.

Kittens should be stimulated to urinate and defecate for the first three weeks. Solid food should be introduced into the diet on approximately day 35 at which time the Esbilac can be increased up to ~43ml per day and the number of feedings reduced to five. By day 60, Esbilac should be reduced to one feeding of ~30ml and can be eliminated entirely by day 80. The amount of solids offered should be gradually

increased to ~140grams by day 90. Artificial heating can be discontinued when the kittens are about five weeks of age as long as the ambient temperature stays between 24-30ºC (75-86ºF) (Partridge 1992).

Raccoons: The formula of choice for these species is KMR® or Milk Matrix® 42/25 (Pet Ag®). Mix one part powder to two parts water by volume for either product after first ensuring that the kit is well hydrated. The kit should be offered 3:1 rehydrating solution to formula, then half and half before being fed 100% formula. The weaning diet should be comprised of soaked puppy chow, Gerber® high-protein baby cereal, and KMR powder with enough water to make up an oatmeal-like consistency. Kits with their eyes still closed may need to be tube feed (DeGhetto et al. 2002).

Coati: The formula of choice is Esbilac®/water mixed at a 1:2 ratio. Day one pups should start with a hydrating formula solution, progressing gradually over several days to a 1:1 formula/water mix then to straight formula. Formula should be kept at 35-37.8°C (95-100°F) or the baby coati will refuse it. All nipples should be the same size, color, and texture or they might refuse the bottle. Pups should be fed every 2 hours until two weeks of age, and every 3 hours until three weeks of age; at this stage rice cereal should be added to the formula (just enough to thicken it). At 3 weeks, the pups should be fed every 4 hours with a mixture of 1 part formula, 2 parts water, 1 part cereal, 1 part baby peaches (jarred) until five weeks of age. At five weeks of age, pups can go 6 hours overnight without feeding them (D. Bressler, personal communication). Since coatis are lactose intolerant, Lactaid® pills should now be added to mixture (2 crushed pills for every 12 scoops of formula) (D. Bressler, personal communication).

Final weaning should not occur before 16 weeks of age (weaning age in the wild). However, weaning may begin at 8 weeks of age with the addition of foods, such as mashed bananas, soaked puppy food, dry puppy food, and scrambled eggs. At this time, the pup should be offered formula in a bottle 4 times a day. Pups should be stimulated to urinate until they are three to four weeks of age. The amount of formula offered should be based on the pups age and weight (see Table 14) (D. Bressler, personal communication).

7.6 Contraception

Many procyonids 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 procyonids are outlined below. More details on products, application, and ordering information can be found on the AZA Wildlife Contraception Center (WCC) webpage: www.stlzoo.org/contraception.

The progestin-based melengestrol acetate (MGA) implant, previously the most widely used contraceptive in zoos, has been associated with uterine and mammary pathology in felids and suspected in other carnivore species (Harrentstein et al 1996, Munson et al 2002, Munson 2006). Other progestins (e.g., Depo-Provera®, Ovaban®) are likely to have the same deleterious effects (e.g., Chittick et al. 2001; Munson et al. 2002). 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 been tested in very few procyonids (e.g., coati).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix J: Sample Procyonid Enrichment Items and Techniques

All items should be evaluated by Animal Care staff for safety and appropriateness. Food items should be accounted for within the individual animal's daily nutritional requirements.

COATIS/RACCOONS

Sensory: auditory, visual, olfactory, tactile

Spices; catnip
Urine/trapping lures
Scented lotions
Body sprays, colognes
Perfume pages
Listerine, diluted
Extracts
Audio tapes
Radio
Paper, paint, stickers, etc. on outside of glass
Sun catcher (presented outside of enclosure)
Hair/wool or feathers
Snake sheds
Bubbles
Hooves
Broom heads/Astroturf for rubbing & scratching
Diluted essential oils
Hides (see hide protocol)
Pinwheels (outside of exhibit)
Laser Pointer
Disco ball (outside of exhibit)
Mirror mobile (outside of exhibit)
Lemons*

Manipulative items/toys

Burlap bag (pillows) stuffed with hay or straw
Cardboard box/tube
Egg carton (without food)
Christmas trees* (unpainted)
Pinecones
Piñatas (without food)
Boomer ball
Coconuts
Paper bags, sticks
Traffic cone
Water cooler jugs w/o food
Busy box child's toy
Fire hose
Phone book
Pine boughs*
Things to bang together to make noise
Durable balls (i.e. basketballs, etc.)*
Frozen Frisbees (water or broth)*
Buckets with holes feeder hung in trees*
Milk crates*

Foods and feeding

Cardboard box/tube
Egg carton feeder
Peanut butter (in some type of device)
Honey (in some type of device)
Marshmallows
Puzzle feeder
Piñatas
Jell-O (in some type of device)
Frozen fruit pops
Insects (crickets, meal/wax worms) in puzzle
Crayfish
Nuts, berries, dried fruit, cob corn & corn stocks
Squash, including pumpkin; melons
Chicken gizzards, breast
Pile of rocks with diet hidden inside
Pinecone feeder
Eggs: hard boiled, scrambled or raw
Bones or Nylabones
Graham crackers
Hanging log puzzle feeder
Water cooler jugs w/ food items
Blue jean feeder*
Acrylic sheet feeder*
Feeder pan*
Acrylic tube feeder in box*
Hanging frozen corn cobs*
Burlap bag feeder*

Physical environment

Sand or sod
Straw/hay, blankets
Logs, stumps, branches
Kiddy pool with sand or leaves
Large hanging baskets (for animals to sleep in)
Coke barrel beds
Linen bed sheets
Water tubs & running water

Behavioral/Social

Visual access to contra specifics (DAF animals)
Visual access to animal decoys, piñatas, etc.)
Approved Training Programs
Window walker

CACOMISTLE/RINGTAIL

Sensory: auditory, visual, tactile, olfactory

Snake skins
Scents - cinnamon and allspice
Urine/Trapping lures
Bath and Body Works body splashes and lotions
Perfume pages from magazines
Diluted extracts
Baby mirrors (unbreakable)
Hooves
Feathers
Non-toxic bubbles
Camel hair/wool
Herbs
Squirrel call
Chalk drawings
Paper, paint, stickers, etc. on outside of glass
Sun catcher (presented outside of enclosure)
Diluted essential oils
Hides (see Hide Protocol)
Disco ball (outside of exhibit)
Mirror mobile (outside of exhibit)

Manipulative items/toys

Paper bags
Paper towels
Small boomer ball
Ferret ball
Piñatas (w/o food)
Antlers
Pine cones
Traffic cones
Newspaper
Burlap bag pillows
Cardboard boxes/tubes
Phone books
Tennis balls
Kong toys
Wiggly Giggly Ball
Fire hose

Behavioral/social

Visual access to contra specifics (DAF animals)
Visual access to decoys & stuffed toys
Window walker

Foods and feeding

Gerbil ball with mealworms inside
Plastic ball smeared lightly with peanut butter
Crickets, meal/wax worms in puzzle device
Bones (if not given on a regular basis)
Pine cone feeders
Pile of rocks in a framed box to hide food in
Cardboard box/tube feeders
Buster Food cube
Egg carton/paper bag feeders
Boomerball puzzle feeder
PVC bug feeder
Piñatas
Sugar free Jell-O (in some type of device)
Frozen fruit pops
Nyla bones/Healthy edibles
Kong toy w/ diet
Carved pumpkins w/ diet
Burlap bags w/ bugs in it
Coconut feeder
Live fish in black tub
Hanging log puzzle feeder

Physical environment

Hanging baskets
Varied substrate
Shredded paper
Approved browse
Snow
Kiddy pool
Logs
Stumps
Cornstalks
Visual barriers
Auto misters
Excelsior
Sod
Large hanging baskets for animals to sleep in
Linen bed sheets

Information taken from: Institution N, Institution O's Enrichment Online*, Institution K

Appendix K: Reproduction in the Kinkajou (*Potos flavus*)

By: Rain Westgard, Kristen Noble, Erin Bussom; Institution P (2009)

Kinkajou (*Potos flavus)* reproduction has not been well studied or documented, either *in-situ* or *ex-situ*. Information for this document comes from personal observations of the kinkajou breeding and training program at Institution P.

Reproductive Physiology and Behavior: Kinkajous reach sexual maturity around 2 years of age for males and 3 years for females. Kinkajous are polyestrous and can have more than one offspring in a single year with a minimum birth interval of 8 months. Estrus is widely variable, even within an individual throughout the year. Estrus cycles average 40 - 60 days with the female in estrus for approximately 3 - 4 days. With such fluctuations, it is important to track estrus cycles of each female by keeping a record of estrus beginning and end as well as behavioral or physical changes and breedings. Swelling of the vulva is typically the only noticeable physical change during estrus. Behaviorally, females may display increased aggression towards staff during estrus. There may be increased marking and territoriality if other females are in range of the estrus individual. Due to the strict nocturnal nature of kinkajous, staff may not even notice behavioral changes.

Copulations between the male and female usually occur at night. The male will approach the female and nip at her mandible and chin, making a soft chirping call. When the female is ready, she will assume a lordosis posture and elevate her tail. The male mounts her from behind. He uses the bony protrusions on his wrists to rub and stroke the abdomen of the female. There may be high pitched squeaks emitted by both. Copulations can last several minutes. Once the male releases the female, the kinkajous will separate and engage in genital grooming. Multiple copulations will occur while the female is in estrus.

Assisted reproduction has not been attempted in kinkajous.

Pregnancy: Gestation for a kinkajou is just under 4 months. Physical changes in the female do not become readily evident until the last trimester. Ultrasound is the most reliable diagnostic tool for detecting pregnancy early and has been used successfully. It is not recommended to anesthetize a pregnant female during the last trimester. If the female is to be moved to another enclosure, every attempt should be made to do so prior to the last trimester. This will provide her ample time to adjust to new surroundings. The male may be left in with the female, if she does not object; multiple elevated nest boxes should to be available for her to choose a nesting site away from him, however. The nest boxes should be dry without substrate or bedding. An external heat source may be used if needed, but ensure that she can move away from it if she chooses.

During the latter part of the second trimester, a defined bulge will become visible in the female's abdomen. In the last trimester, the female's lower abdomen will become much more pronounced as the baby "drops". Fetal movement will be observable and fetal activity will increase as parturition draws near. The female will clear her two inguinal teats a few days prior to parturition and her mammary glands will swell as milk is letdown. During the entire last trimester, the female's appetite and caloric needs also will increase significantly and her diet should be increased at this time. Typically, the diet should be increased ~35 – 40% (for 2 adults housed together); all dietary items are increased equally. However, there may be an actual decrease in diet consumption just prior to parturition. The female may experience some physical discomfort as the fetus grows and occupies more space in her body, so increased stretching and restlessness may be observed, especially in the last trimester.

Parturition: Behaviorally, the female may exhibit some anxiety and agitation as her pregnancy progresses. She will drive the male away from her proximity at some point shortly before parturition, often just a few hours, but occasionally a few days before giving birth. He will stay away from the female and offspring until the female allows him to return to her nest. This reacceptance can take a couple of days or a couple of weeks. The female almost always gives birth overnight or during very early morning hours. She will chew off the umbilicus and consume all membranes and the placenta once it has passed.

Institution P had one kinkajou that occasionally experienced a uterine prolapse following parturition; however, this does not appear to be a common occurrence. If a prolapse occurs, immediate veterinary intervention is advised. Every attempt should be made to keep the offspring with the dam for as long as possible prior to repair of the prolapse and reintroductions should be attempted as soon as the dam has recovered from anesthesia. The offspring will require supplemental care while the dam is in surgery.

Following parturition, efforts should be made to keep the environment quiet and stable for at least two weeks, allowing the female to bond with the offspring. Females will aggressively defend the nest if they feel threatened, so only staff familiar to the kinkajou should work in the area if possible. Husbandry efforts should be kept to a minimum while maintaining good sanitation. This should continue until the female is comfortable and relaxed around staff. If the male is present in the enclosure, he will have no active part in rearing the offspring, but also will defend the nest if the female is threatened.

Kinkajou Young: The newborn kinkajou is altricial and should begin to nurse within a few hours of birth. Typical birth weights range between 150 and 180 grams. It is not unusual to see the newborn lying away from the mother in the same nest box for extended periods, especially in hot weather. It will lie next to or on top of the dam and nurse frequently throughout the day and night and will sometimes favor one teat over the other. If the diet of the female has not yet been increased, it must be increased to maintain lactation and provide proper nutrition for the infant. The diet increase should range between 35 and 40% of the female's maintenance diet; all dietary items should be increased equally. If the female loses an infant, she typically will have an estrus cycle within a few days.

Young kinkajous' eyes begin opening at about 1 week of age. Weight should increase steadily reaching ~200 – 270g at 1 week, 600 – 800g at 6 weeks, and 1.3 – 1.7kg at 6 months when they are roughly 75% adult size. The young become independently mobile at about 5 to 6 weeks and will begin showing an interest in solid food being eaten by their mother around 8 weeks of age. At about 10 to 12 weeks of age they will begin to consume solid foods taken from their mother and are typically weaned by 14 to 16 weeks. A young kinkajou will continue nursing as long as the mother allows, even after they have begun consuming the majority of their calories from solid foods. Food amounts offered should be increased to accommodate weanlings.