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## NUTRITION ADVISORY GROUP HANDBOOK



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### ASIAN SMALL-CLAWED OTTERS: NUTRITION and DIETARY HUSBANDRY<sup>a</sup>

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To sustain a captive population of Asian small-clawed otters, the nutritional needs of the species must be met. Developing appropriate dietary guidelines requires consideration of (1) feeding ecology, (2) target dietary nutrient values, (3) food items available to zoos, and (4) information on diets offered by institutions successfully maintaining and breeding them. This paper will address these nutritional issues in order to develop dietary guidelines for captive Asian small-clawed otters.

#### Feeding Ecology

The Asian small-clawed otter (*Aonyx cinerea*; hereafter Asc otter) is a member of the Mustelidae family. The free-ranging Asc otter is a carnivore that regularly consumes crabs, crustaceans, snails, mollusks, frogs, and fish (Table 1).<sup>6,10,11,13</sup> Partridge and Jordan also observed consumption of octopus.<sup>18</sup>

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<sup>a</sup> Adapted in part from Maslanka, M., and S. Crissey. 1998. Nutrition and diet. *In* Lombardi, D., and J. O'Conner (eds.). *The Asian Small-Clawed Otter Husbandry Manual*. Columbus Zoo, Columbus, OH.

## **Nutrient content of diet**

Although many of the foods in the diet of free-ranging Asc otters are known, the nutrient content of those items has not been completely characterized. Descriptions of the nutrient content of similar food items (although sometimes in distinctly different forms) can be found in several sources.<sup>17,19</sup> However complete nutrient information remains limited, and, as a result, estimates of free-ranging nutrient intake should be used with caution.

## **Target Dietary Nutrient Values**

Target dietary nutrient values for Asc otters are based on several sources. The cat is typically used as a model species to establish nutrient guidelines for carnivores. The NRC,<sup>16</sup> AAFCO,<sup>1</sup> and Waltham Center for Pet Nutrition<sup>7</sup> have provided nutrient recommendations for cats. A limited amount of information for another mustelid species is provided in the NRC publication on Nutrient Requirements for Mink and Foxes.<sup>17</sup> The target nutrient concentrations in Table 4 are presented as a range of values derived from these sources. In most cases, they reflect the highest values reported. As additional information becomes available, these ranges should be adjusted to reflect new knowledge.

## **Food Items Available to Zoos**

Historically, diets for captive Asc otters have revolved around meat products, with supplements to compensate for perceived nutrient shortfalls.<sup>2</sup> Minced beef, fish, hard-boiled eggs, and locally available shellfish and crabs all have been provided.<sup>14,23</sup> In a recent attempt to more closely match composition of the free-ranging Asc otter diet, locally obtained shellfish (crabs, clams, and crayfish) and fish have been increased in proportion to meat.<sup>15</sup>

## **Summary of Diets Offered by U.S. Zoos**

Information collected on diets used by institutions successfully holding Asc otters can be helpful in preparing dietary guidelines. To gather this information, a nutrition section was included in a recent survey, and the results were subsequently published in the Asc Otter Husbandry Manual. The results of the survey established that a number of different diets have been used. Food items offered included manufactured feeds, meat products, fish/seafood, insects, vegetables, and supplements. Manufactured feeds included ZuPreem Canned Feline Diet (Hills' Pet Products, P.O. Box 148, Topeka, KS 66601), Purina Dog Food (Ralston Purina Co., St. Louis, MO 63164), Nebraska Brand Feline Diet (Central Nebraska Packing, Inc. P.O. 550, North Platte, NE 69103-0550), Purina Fit'n'Trim dog food (Ralston Purina Co.), Nutrena Dog Food (Nutrena Feeds, 2101 Terminal Rd, Fort Worth, TX 76106), Iams Less Active Dog Food (Iams, Co., 7250 Poe Ave. Dayton, OH 45414), Cycle Lite (Heinz Pet Products, Heinz, Inc. Newport, KY 41071), Wisconsin Meat Mix (Animal Food Services, Iola, WI 54945), and Nebraska Brand Bird of Prey Diet. Meat products included beef, horse liver, and ribs. Some institutions included vertebrate prey (mice and chicks). Seafood items included a wide variety of fish (capelin, smelt, mackerel, herring, goldfish, minnows, trout, and cichlids), shellfish (clams), and other crustaceans (crayfish). Invertebrates included mealworms, crickets, and earthworms. A variety of

vegetables (carrots, lettuce, green beans, lettuce, cucumbers, collard greens, kale, and assorted greens) have been offered, as well. Supplements included vitamin E, corn oil, children's vitamins, thiamin, vitamin E/thiamin (in combination), Linatone (Lambert Kay, Inc. Division of Cater-Wallace, Inc. Cranbury, NJ 08512-0187), vitamin B-complex, Vitasol with Vitamin E (Mead Johnson Nutritionals, Evansville, IN 47721), potassium citrate granules (Landco, Division of Golden Crown Corp., Post Falls, ID 83854), and chitin.

In most cases (14 out of 19 surveyed institutions), food items offered were measured either by weight or volume. Consumption also was measured in 14 out of 19 institutions, but only by visual appraisal.

While all foods were considered part of a complete and balanced diet, several institutions offered certain items principally for behavioral enrichment. Other institutions used these same items as a significant part of the basic diet. Live foods used for enrichment included crayfish, crabs, fish, crickets, and mealworms. Other behavioral enrichment items, occasionally offered, included mussels, clams, hard-boiled eggs, peanuts, and items, such as crickets or fish, frozen into ice cubes.

Seasonal variations in diets offered were due to the periodically limited availability of some foods. At institutions where otters were housed outdoors (or in areas with little temperature regulation), food consumption increased as winter temperatures decreased.

### **Feeding schedule/interval**

Most institutions represented in this survey offered food twice daily (morning and evening). Several institutions offered food more often (3 to 15 times per day). Food items were offered both on and off exhibit, depending upon the item(s) and the desired presentation.

### **Water**

Most institutions provided potable water via simulated streams and/or pools. Some offered drinking water in separate tubs. Most of the institutions reported that pool water was not heated and was maintained at a temperature of 65-80° F.

### **Nutrient content of total diets**

Several institutions have had their diets analyzed in a laboratory or nutrient concentrations estimated via computer programs. The ingredients in those diets are listed in Table 2, and nutrient concentrations are listed in Table 3. Two of the diets were fish-based (Audubon Zoo and Minnesota Zoo), and appeared comparable in concentrations of many of the nutrients.

### **Behavior related to feeding**

Most institutions have observed competitive behavior for offered food items. In some cases, this competition was manifested as aggression. This has led to physical separation of individuals at feeding time or to offering food in separate areas of the exhibit. It has been reported that Asc otters adapt well to routines, learn the precise time of feeding each day, and, in many cases, vocalize at feeding time.

Several institutions have observed food-begging behavior. Once fed, otters may wash their food. In mixed species exhibits, other animals may steal the otters' food and vice versa, but little interspecies aggression has been observed.

### **Alternative diets**

Several institutions have employed alternative diets for special circumstances, such as for lactating females (KMR [Pet Ag, Inc. 261 Keyes Ave., Hampshire, IL 60140] and added calcium carbonate), promotion of weight loss, growing juveniles (Science Diet Growth Formula), maintenance of non-breeding adults (Science Diet Maintenance), and in attempts to reduce renal calculi (Science Diet K/D, C/D). Few details were provided regarding the specific circumstances that prevailed when alternative diets were used.

### **Feeding Recommendations**

Diet formulations should consider animal preferences, body weight, physical condition, environmental/seasonal effects, behavior, food item availability, gastrointestinal tract morphology, and the impact of these factors upon nutrient requirements. Thus, guidelines for the nutrient content of diets rather than for specific food items in set quantities are presented in Table 4. These allow flexibility in diet formulation while assuring that nutrient needs are met. Diets based on meats, meat mixes, and/or fish have been used successfully to maintain captive Asc otters in the U.S. Feeding mustelids at least two times per day is recommended due to their high metabolic rate and rapid digesta passage rate.<sup>18</sup>

### **Diets**

As mentioned previously, several basic diets (including fish and commercially available dry, canned, and frozen diets) have been used to maintain Asc otters in captivity.<sup>2</sup> Meat-based diets have been used in most institutions for growth, maintenance, and breeding. There is a variety of meat products upon which the diet may be based. Table 5 briefly describes nutrient concentrations in some commonly used manufactured products that are intended to be nutritionally complete. Although no definitive cause and effect relationship has been established, many Asc otters offered meat-based diets have developed renal calculi (see **Health Problems Associated with Diet** and the **Health** chapter in the **Asc Otter Husbandry Manual**). It must be noted however, that most otters receive this type of diet and most have this problem, so the involvement of a particular dietary component is difficult to identify.

With the observation that renal calculi are seen almost solely in captive Asc otters, a diet more closely resembling the reported free-ranging diet has been developed in an attempt to reduce their incidence in captivity. This is a fish-based diet that has been evaluated for 3-4 yr at the Minnesota Zoo, and appears to offer some promise.<sup>21</sup> Alternatively, some institutions have historically offered Asc otters all-fish diets with little, if any, reduction in the incidence of renal calculi.<sup>20</sup> Common fish species and marine products, and their nutrient concentrations, that could be included in an "all-fish" diet are listed in Table 6. Supplements of vitamin E, thiamin, and possibly multivitamins may be especially important when offering diets comprised mostly of fish (see **Nutrient supplements** section). Also,

offering bones or some hard dietary item on at least a weekly basis, regardless of the remainder of the diet, is recommended to maintain oral health.

Suggestions for alternative items or diets that might be tried are discussed in the **Future Research** section. Use of potassium citrate has offered some promise in minimizing the incidence of renal calculi in dogs and cats via inhibition of crystallization, formation of complexes with calcium, and acidification of the urine.<sup>21</sup> Pyridoxine has been successful in treating some cases of calcium oxalate uroliths in humans. However, the benefit to Asc otters of either course of action has not been proven.

## **Nutrient supplements**

**Vitamin E and thiamin.** Diets which contain high levels of marine products may predispose individuals to vitamin E deficiency if not adequately supplemented.<sup>8</sup> Marine products contain high levels of poly- and mono-unsaturated fatty acids. Because vitamin E functions as an antioxidant, the tendency for these fatty acids to undergo peroxidation during storage results in vitamin E destruction. Thiamin deficiency may arise due to thiaminases that are particularly active during storage of some species of fish. If fish are offered as a major component of the total diet, supplements of vitamin E and thiamin are recommended (see **Target Dietary Nutrient Values**). The need for these supplements should be addressed during the diet formulation process.

**Multivitamins.** In some cases, if a fish-based diet is used, supplementation with a multivitamin preparation might be considered. Deficiencies of vitamins, other than vitamin E and thiamin, have been reported in some commercially farmed mustelids.<sup>17</sup> Fish composition can differ, based on species, season of harvest, and duration of storage, and a multivitamin supplement may provide some consistency in dietary nutrient concentrations. However, this issue needs to be carefully evaluated (including a possible dietary analysis) to avoid over-supplementation and induction of toxicities, particularly of fat-soluble vitamins.

## **Hand-Rearing / Infant Diet**

The **AZA Infant Diet Notebook** provides some insight into hand-rearing mustelid species.<sup>4</sup> Table 6 describes mustelid milk composition. According to Burnette, the milk-replacement formula of choice appears to be Esbilac Dog Milk Replacer (Pet Ag, Inc., 261 Keyes Ave., Hampshire, IL 60140).<sup>4</sup> This notebook is being revised by the AZA Nutrition Advisory Group and should soon provide updated guidelines. Additionally, Milk Matrix 30/55 (Pet Ag) has been successfully used to hand-rear other mustelid species.

If hand-rearing is necessary, and formula is to be offered via a bottle, 100% water should be offered at the outset with a gradual transition/mixing of formula to achieve 100% formula over a period of several feedings. This will allow the infant to become used to the nipple or other feeding device, and minimize the risks associated with fluid aspiration. It also will minimize the potential for diarrhea caused by a sudden dietary change.

Newborn and/or weak infants should be fed every 2-3 hr, around the clock. After 10 days, feedings can be reduced to every 3-4 hr, still maintaining overnight feeding. As the animals grow, frequency of feedings can be gradually reduced to 3-4 feedings per day until weaning at about 82-120 days.<sup>4</sup>

Amounts of formula to offer depend upon size, age, and health. As noted in the AZA Infant Diet Notebook, “feed until the stomach is full but not taut or over-extended.” However, discretion is required because the concept that an infant will correctly control its intake, when milk is offered ad libitum, has been proven incorrect by numerous reports of diarrhea, vomiting, listlessness, potbellies, labored breathing, anorexia, and death.<sup>22</sup> Thus, ad libitum feeding is discouraged. It is best to establish moderate intake guidelines at the beginning of hand-rearing and to adjust them, based on observations of the relationship between formula consumption and growth.

## Alternative Diets

### Lactation diet

There is an increased need for energy during lactation. Tumarov and Sorina have proposed the development and use of high-energy diets for lactating mustelids by increasing dietary fat concentrations and feeding at levels that will support lactation and minimize mobilization of body energy stores and the metabolic stress associated with milk production.<sup>24</sup> Increases in dietary energy density and amounts fed should be based on past experience with individual lactating otters or on observations of changes in body condition or body weight.

### Weight-loss diet

There are several ways to formulate a weight-loss diet for otters. Depending upon the food items available, whether otters are fed alone or in a group, and the amount of weight loss desired, one or more of the following approaches may be appropriate.

**Offer less total food.** By simply reducing the amount of total food offered, weight loss may occur. This practice is confounded by the aggression observed in group-fed Asc otters at feeding time and the potential for more aggression when less food is offered.

**Add water to the diet.** By providing a diet containing more moisture, the energy-yielding components of the diet will be diluted and may allow for weight loss, assuming no increase in total diet consumption. If restricted to consumption of the same weight of total diet, fewer calories would be consumed.

**Add fiber to the diet.** By adding indigestible items such as cellulosic fiber to the diet, fewer calories will be available in the same quantity of dry matter. Thus, otters can consume the same amount of food, but will acquire fewer calories.

**Offer lower calorie items.** Fish species vary in energy content, and if weight loss is desired, a leaner fish could be substituted for a fattier fish, thus reducing total dietary calories.

## Health Problems Associated with Diet

In 1985, the major captive husbandry problem, as reported in the regional Asc otter studbook, was the occurrence of urinary stones, or calculi.<sup>11</sup> At that time, calculi appeared to develop regardless of the diet offered (meat mixes, commercial diets for cats or dogs, thawed fish, or table scraps). In 1988, when the Asc otter SSP program was developed, calculi were reported as the primary cause of death in

the North American population.<sup>12</sup> That year, it was reported that calculi had been observed in over 75% of captive Asc otters in the U.S.,<sup>5</sup> and apparently calculi are still prevalent, based on the recent institutional survey. Eight out of 19 institutions reported no nutritionally related disorders in their otters. Of the institutions that reported nutritional disorders, all reported renal calculi (or “renal problems”). To deal with these problems, research has been instituted to determine the cause of renal calculi in Asc otters and to develop management techniques that might minimize their incidence.<sup>21</sup> This research has led to the conclusion that calculi formation in Asc otters is caused by a multitude of complex and interrelated factors. Several dietary adjustments have been attempted (all-fish diets, potassium citrate additions, chitin additions, special prescription diets). However, few of these adjustments have been examined in controlled studies for periods of time sufficient to produce unequivocal evidence of their effectiveness.

### **Future Research Needs**

Studies examining the efficacy of all-fish diets in reducing the incidence or growth of renal calculi have been ongoing for several years, but with mixed results. Work performed at the Minnesota Zoo over 3 yr has shown some promise, and it will be important to observe these otters over the next few years, as well.<sup>21</sup> The effects of renal calculi are sufficiently serious that identification of causes and development of preventive measures should receive major research attention. With this in mind, several issues might be considered in directing future research efforts:

(1) Between 70 and 80% of captive Asc otters, offered a variety of diets, have developed renal calculi.

(2) Although some otters offered an all-fish diet have developed calculi, Asc otters at the Minnesota Zoo have not exhibited calculi after being fed an all-fish diet for over 3 yr.

(3) Several dietary items have been introduced that might assist in reducing the incidence of renal calculi, but none have been adequately tested in controlled studies. These include potassium citrate and Hill’s Feline C/D.

(4) Several young otters (assumed calculi-free at this point) in the North American population could be used in evaluation of a selected diet throughout their lives. It is recommended that all young otters be thoroughly evaluated initially, and periodically thereafter, including radiographs of the urinary system. Since the number of animals at any one institution is relatively small, collaborative investigation is a necessity. This collaboration should involve standardized protocols and management guidelines, and should test a uniform diet (such as fish and specific supplements), with controls if possible, among all participating institutions.

### **Literature Cited**

<sup>1</sup> AAFCO. 1999. Official Publication. Association of American Feed Control Officials, Inc., Atlanta, GA.

<sup>2</sup> Baer, D.J., M.E. Allen, and J. Letcher. 1994. Use of natural and processed diets for small-clawed otters (*Aonyx cinerea*). Pp. 305-307 in Proc. AAZV Conf. Pittsburgh, PA.

<sup>3</sup> Bernard, J., and D.E. Ullrey. 1989. Evaluation of dietary husbandry of marine mammals at two major zoological parks. J. Zoo Wildl. Med. 20: 45-52.

- <sup>4</sup> Burnette, C. 1994. Hand-rearing Mustelids. Pp. 13-1-13-7 in *The AZA Infant Diet Notebook*. AZA Publication, Oglebay Park, Wheeling, WV.
- <sup>5</sup> Calle, P. 1988. Asian small-clawed otter (*Aonyx cinerea*): urolithiasis prevalence in North America. *Zoo Biol.* 7:233-242.
- <sup>6</sup> DuPlaix-Hall, N. 1975. River otters in captivity. Pp. 178-181 in Martin, R.D. (ed.). *Breeding Endangered Species in Captivity*. Academic Press, London.
- <sup>7</sup> Earle, K.E., and P.M. Smith. 1993. A balanced diet for dogs and cats. Pp. 45-55 in Burger, I.H. (ed.). *The Waltham Book of Companion Animal Nutrition*. Pergamon Press, New York, NY.
- <sup>8</sup> Engberg, R.M., K. Jakobsen, C.F. Borsting, and H. Gjerm. 1993. On the utilization, retention, and status of vitamin E in mink (*Mustela vison*) under dietary oxidative stress. *J. Anim. Physiol.* 69:66-78.
- <sup>9</sup> Engelhardt, F.R., and J.R. Geraci. 1978. Effects of experimental vitamin E deprivation in the Harp seal (*Phoca groenlandica*). *Can. J. Zool.* 56:2186-2193.
- <sup>10</sup> Engfer, S. 1986. Asian Small-Clawed Otter (*Aonyx cinerea*) North American Regional Studbook. AZA Publication. Oglebay Park, Wheeling, WV.
- <sup>11</sup> Foster-Turley, P. 1985. Asian Small-Clawed Otter (*Aonyx cinerea*) North American Regional Studbook. AZA Publication. Oglebay Park, Wheeling, WV.
- <sup>12</sup> Foster-Turley, P., and S. Engfer. 1988. The species survival plan for the Asian small-clawed otter (*Aonyx cinerea*). *Int. Zoo Yrbk.* 27:79-84.
- <sup>13</sup> Foster-Turley, P. 1992. Conservation Ecology of Sympatric Asian Otters (*Aonyx cinerea* and *Lutra perspicillata*). Ph.D. Dissertation. University of Florida, Gainesville.
- <sup>14</sup> Lancaster, W.E. 1975. Exhibiting and breeding the Asian small-clawed otter (*Amblonyx cinerea*) at Adelaide Zoo. *Int. Zoo Yrbk.* 15:63-65.
- <sup>15</sup> Maslanka, M.T., and S.D. Crissey. 1998. Nutrition and diet. Pp. 1-18 in Lombardi, D., and J. O'Connor (eds.). *Asian Small-Clawed Otter (Aonyx cinerea)*. Columbus Zoological Gardens and AZA Asian Small-Clawed Otter SSP.
- <sup>16</sup> National Research Council. 1986. *Nutrient Requirements of Cats*. National Academy Press, Washington, DC.
- <sup>17</sup> National Research Council. 1982. *Nutrient Requirements of Mink and Foxes*. National Academy Press, Washington, DC.
- <sup>18</sup> Partridge, J., and M. Jordan. 1995. *Husbandry Handbook for Mustelids*. The Association of British Wild Animal Keepers. Top Copy, Bristol, UK.
- <sup>19</sup> Pennington, J.A.T. 1989. *Bowes and Church's Food Values of Portions Commonly Used*, 15<sup>th</sup> Ed. Harper and Row Publishers, New York, NY.
- <sup>20</sup> Petrini, K. personal communication.
- <sup>21</sup> Petrini, K., L.J. Trechsel, D.M. Wilson, and J.H. Bergert. 1996. The effects of an all fish diet on urinary metabolites and calcium oxalate supersaturation of Asian small-clawed otters (*Aonyx cinerea*). Pp. 508-517 in *Proc AAZV Conf.*, Puerto Vallarta, Mexico.
- <sup>22</sup> Robbins, C.T. 1993. *Wildlife Feeding and Nutrition*, 2<sup>nd</sup> Ed. Academic Press, San Diego, CA.



<sup>23</sup> Timmins, W.H. 1971. Observations on breeding the Oriental short-clawed otter (*Amblonyx cinerea*). Int. Zoo Yrbk. 11:109-111.

<sup>24</sup> Tumanov, I.L., and E.A. Sorina. 1997. Dynamics of nutritional energetics of female mustelids. Pp. 10-14 in Small Carnivore Conservation - The Newsletter and Journal of the IUCN/SSC Mustelid, Viverrid, and Procyonid Specialist Group. No. 17 (Oct). Edegem, Belgium.

<sup>25</sup> Ullrey, D.E. 1996. Skepticism and science: responsibilities of the comparative nutritionist. Zoo Biol. 15:449-453.

**Table 1.** Prey items listed in order of frequency of occurrence in the scat of free-ranging Asc otters.<sup>13</sup>

Prey item
Invertebrates (general)
Crabs
Fish (general)
Gobiodei (mudskippers)
Anabantidae (specific fish family)
Snakes (general)
<i>Trichogaster</i> spp. (fish spp.)
<i>Anabis testudineus</i>
Amphibians (general)
<i>Rattus</i> spp.
Snails
<i>Clarias</i> spp. (fish spp.)

**Table 2.** Percent distribution of food items in representative diets of captive Asc otters (weight as fed; 1997 survey results).

Audubon Zoo	Brookfield Zoo	WCS (Bronx)	Minnesota – fish <sup>a</sup>	Minnesota – meat <sup>a</sup>
46.6% Mackerel	58% Otter Mix <sup>c</sup>	50% Feline Diet <sup>e</sup>	28.6% Capelin	100% Feline Diet <sup>e</sup>
20.6% Capelin	30% Fish <sup>d</sup>	18% Capelin	28.6% Mackerel	
16.8% Herring	8% Ribs	18% Carrot/Yam	28.6% Herring	
9.2% Smelt	2% Dog food	14% Greens	14.3% Smelt	
6.4% Corn oil	2% Invertebrates	Thiamin/E	1.9% Corn oil	
0.2% Multivitamin <sup>b</sup>			0.2% Thiamin/E	
0.1% Vitamin E			Multivitamin <sup>b</sup>	
0.1% Thiamin				

<sup>a</sup>Two experimental diets have been used at the Minnesota Zoo: a fish-based diet and a meat-based diet. These diets have been used to examine the incidence of renal calculi.<sup>21</sup>

<sup>b</sup>Multivitamin was a Children’s Multivitamin (Audubon) or A-Z Multivitamin (Minnesota).

<sup>c</sup>Otter Mix contained 30% low-calorie dog food, 27.6% Nebraska ground horsemeat, 14.9% ground beef heart, 12.3% water, 9.1% ground cat food, 2.7% poultry fat, 2.1% beet pulp, 0.58% CaCO<sub>3</sub>, 0.44% corn oil, 0.3% theralin substitute, 0.0001% Rovimix-E.

<sup>3</sup>Capelin, smelt, and herring.

<sup>4</sup>Nebraska Brand Feline Diet.

**Table 3.** Analyzed nutrient concentrations (dry matter basis) in representative diets offered to captive Asc otters.<sup>a</sup>

Nutrient	Audubon Zoo diet	Brookfield Zoo diet	WCS (Bronx) diet	Minnesota fish diet	Minnesota meat diet
Dry matter, %	25.3	56.0	60.6	24.8	39.3
Crude protein, %	66.6	42.9	53.7	68.1	47.8
Fat, %	24.1	18.4	36.6	18.95	37.9
Crude fiber, %	1.02	4.5	-	1.2	2.8
Ash, %	9.56	6.2	-	10.4	6.5
Na, %	0.43	0.27	-	0.79	0.32
Ca, %	3.26	0.82	1.3	1.56	0.96
P, %	1.14	0.55	1.1	1.67	0.78
K, %	1.44	0.90	-	1.5	0.88
Mg, %	0.18	0.12	-	0.16	0.1
Zn, mg/kg	57.3	54.7	-	78.8	73.5
Cu, mg/kg	2.18	7.36	-	3.34	7.9
Mn, mg/kg	- <sup>b</sup>	6.8	-	4.69	18.6
Fe, mg/kg	70.8	154.1	-	103.5	483

<sup>a</sup>Diets were analyzed at multiple sites (based on institutional affiliation and/or preference).

<sup>b</sup>- indicates unknown value.

**Table 4.** Target dietary nutrient ranges for Asian small-clawed otters (dry matter basis).

Item	Target nutrient range <sup>a</sup>
Metab. energy, kcal/g	3.6-4.0
Crude protein, %	24-32.5
Fat, %	15-30 <sup>b</sup>
Vitamin A, IU/g	3.3-10 <sup>c</sup>
Vitamin D, IU/g	0.5-1.0
Vitamin E, mg/kg	30-120 <sup>d</sup>
Thiamin, mg/kg	1-5 <sup>d</sup>
Riboflavin, mg/kg	3.7-4.0
Pantothenic acid, mg/kg	5-7.4
Niacin, mg/kg	9.6-40
Pyridoxine, mg/kg	1.8-4
Folic acid, mg/kg	0.2-1.3
Biotin, mg/kg	0.07-0.08
Vitamin B <sub>12</sub> , mg/kg	0.02-0.025
Choline, mg/kg	1000-3000
Calcium, %	0.6-0.8 <sup>e</sup>
Phosphorus, %	0.6 <sup>e</sup>
Potassium, %	0.2-0.4
Sodium, %	0.04-0.6
Magnesium, %	0.04-0.07
Zinc, mg/kg	50-94
Copper, mg/kg	5.0-6.25
Manganese, mg/kg	5-9
Iron, mg/kg	80-114
Iodine, mg/kg	1.4-4.0

<sup>a</sup>Target nutrient ranges on a dry matter basis derived from requirements for domestic cats,<sup>16</sup> AAFCO recommendations,<sup>1</sup> Waltham Center for Pet Nutrition recommendations,<sup>7</sup> requirements for mink and foxes,<sup>17</sup> and literature describing the foraging behavior of Asc otters.

<sup>b</sup>The fat content of fish commercially available in North America typically ranges from 5-40%, and Asc otters have been maintained on diets containing between 15-40% fat (see Tables 2 and 3). Thus, an appropriate range for fat appears to fall between 15-30%. The requirement for fat corresponds to a requirement for energy as well as specific fatty acids.

<sup>c</sup>The vitamin A requirement for cats is 10 IU/g (dry matter basis),<sup>16</sup> which represents the upper bound of the range. However, free-ranging Asc otters may consume a diet of mostly fish,<sup>13</sup> thus may have a higher tolerance for vitamin A due to the high levels which may occur in their natural diet.

<sup>d</sup>When mostly fish diets are offered, the presence of unsaturated fatty acids and thiaminases causes the breakdown of these vitamins. Thus, dietary levels of 400 IU vitamin E/kg of dry diet and 100-120 mg thiamin/kg of dry diet are recommended.<sup>9</sup>

<sup>e</sup>The recommended Ca:P ratio is between 1:1 and 2:1.

**Table 5.** Nutrient content of several commonly used meat/nutritionally complete food items (dry matter basis).<sup>a</sup>

Nutrient	Ground horsemeat	Nebraska Feline ®	Nutrena River Run Dog Food ®	Purina Fit 'n' Trim Dog Food ®
Crude protein, %	51.7	50.0	23.9	18.2
Fat, %	19.7	31.6	9.1	5.7
Vitamin A, IU/g	-	97.1	5.7	20.1
Vitamin D, IU/g	-	1.2	5.7	2.0
Vitamin E, mg/kg	-	42.4	56.8	12.5
Ca, %	-	1.6	1.7	1.1
P, %	-	1.3	1.1	0.9
Mg, %	-	0.05	0.05	0.2

<sup>a</sup>Values from manufacturers' guaranteed analysis and analyses performed at or for Brookfield Zoo.

**Table 6.** Nutrient content of several commercially available fish species and marine products (dry matter basis).<sup>a</sup>

Nutrient	Capelin	Herring	Oystershell	Shrimp <sup>17,19</sup>	Smelt	Trout
Dry matter, %	18.8	27.7	100	24.1	22.7	23.7
GE, kcal/g	5.5	6.3	-	2.3	7.0	6.5
Crude protein, %	59.8	45.3	0	20.5-44.2	70.4	55.8
Fat, %	14.8	34.0	0	1.8-4.3	16.6	34.5
Vitamin A, IU/g	44	56	0	-	-	58
Vitamin E, IU/g	0.024	0.034	0	-	-	0.32
Ca, %	1.7	1.7	38.0	10.8	1.4	2.1
P, %	1.7(1.2-1.4) <sup>b</sup>	1.3	0.07	2.1	1.6	1.5

<sup>a</sup>Analyses from Bernard and Ullrey<sup>3</sup> (with corrected P values)<sup>25</sup>, Minnesota Zoo, and Brookfield Zoo, unless otherwise noted.

<sup>b</sup>Unpublished data from the Brookfield Zoo and Minnesota Zoo.

**Table 7.** Milk composition of several mustelid species.<sup>4,22</sup>

Species	% Water	% Solids	% of Solids		
			Fat	Protein	Carbohydrate
N.Amer. river otter	62.0	38.0	63.0	28.9	0.3
Sea otter	69.9	30.1	65.0	31.2	2.6
Mink	78.3	21.7	33.0	26.0	21.0
Mink	68.9	31.1	30.1	29.6	-
Badger	81.4	18.6	33.9	38.7	18.8
Ferret	76.5	23.5	34.0	25.5	16.2
Hog-nose skunk	65.4	34.6	31.2	31.2	7.8
Striped skunk	69.4	30.6	45.0	32.0	10.0