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Authors: Mainka, S. A., Mao, Li, and Guanlu, Zhao

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Dietary Vitamin and Mineral Concentrations of Two Juvenile Female Giant Pandas (*Ailuropoda melanoleuca*)

S. A. Mainka,[1] **Li Mao, and Zhao Guanlu,**[2] [1] Veterinary Services, Calgary Zoo, P.O. Box 3036, Station B, Calgary, Alberta, Canada T2M 4R8; [2] Chongqing Zoo, Sichuan Province, Chongqing, China

ABSTRACT: During a 7 mo exhibit loan, diets of two juvenile female giant pandas (*Ailuropoda melanoleuca*) were monitored. Mineral [calcium (Ca), copper (Cu), phosphorus (P), potassium (K), zinc (Zn)] and vitamin (beta-carotene and total tocopherol) concentrations in the diet were quantified as well as in a serum sample obtained from one of these animals. Diets consumed by the pandas contained (dry matter basis): 0.82% Ca, 0.62% P, 1.05% K, 14.3 mg/kg Cu, 31.8 mg/kg Zn, 12.2 mg/kg beta-carotene, and 12 mg/kg total tocopherol. Serum values for these vitamins and minerals were within reported normal limits for the spectacled bear (*Tremarctos ornatus*). This diet appeared to provide adequate nutrition for maintenance and growth.

Key words: Giant panda, *Ailuropoda melanoleuca,* nutrition, minerals, vitamins, diets.

Recent work at the Wolong Natural Reserve (People's Republic of China; 30°45′ to 31°25′N, 102°52′ to 103°24′E) correlating the mineral content of hair and diet has shown higher mineral levels in wild pandas (*Ailuropoda melanoleuca*) (n = 115) compared to captive pandas (n = 21). In particular, levels of calcium (Ca), copper (Cu), iron, magnesium, manganese, potassium (K) and zinc (Zn) were studied (Wen et al., 1988). Also, a correlation between trace element concentration of food items and captive panda hair was seen.

During a recent short-term exhibit loan, two female giant pandas were the subjects of a digestive efficiency study (Mainka et al., 1989). They were fed a diet of bamboo, gruel, apples and sugar cane. In addition, each panda received supplements of d-alpha-tocopherol acetate (the 2.5-yr-old received 125 mg, the 4.5-yr-old received 250 mg) and vitamin A in cod liver oil (the 2.5-yr-old received 5,000 IU; the 4.5-yr-old received 10,000 IU) added to the gruel each day. Bamboo was shipped from San Diego and was not received at the zoo until at least 48 hr post-cutting. Samples (minimum 100 g) of golden bamboo (*Phyllostachys aurea*) and umbrella bamboo (*Fargesia spathaceus*) were analyzed for levels of Ca, Cu, K, P and Zn as well as beta-carotene (β-CAR) and total tocopherol (T-TOC). The bamboo plants were divided into culm, branch, leaf and shoot (*P. aurea* only) for analysis. Umbrella bamboo culm was divided into bark and pith for analysis. Samples of other diet items were subjected to the same analyses. Minerals, B-CAR and T-TOC concentrations in food items were assayed according to the methods of the Association of Official Analytical Chemists (AOAC) (Horwitz, 1975) via atomic absorption (minerals) and high performance liquid chromatography (β-CAR, T-TOC)

A single venous blood sample from the older panda was collected during anaesthesia with ketamine/isoflurane. Retinol (RET) and alpha-tocopherol (α-TOC) levels in serum were determined at the Animal Health Center, New York Zoological Society (Bronx, New York 10460, USA) using HPLC (Hatam and Kayden, 1979). Serum biochemistry and electrolyte values were determined (Central Lab for Veterinarians, Langley, British Columbia, Canada V3A 1H9) and serum Cu and Zn determinations were done using atomic absorption spectrophotometry (Alberta Agriculture Lab, Edmonton, Alberta, Canada T6H 4P2). Information on the mineral concentration of drinking water was obtained from the City of Calgary Engineering Department (Calgary, Alberta, Canada T2G 2M3).

Mineral and vitamin concentration of the dietary ingredients on a dry matter (DM) basis are shown in Table 1. Bamboo leaves had higher levels of β-CAR and

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TABLE 1. Mineral and vitamin content (DM basis) in various food items in the diet of two giant pandas.

Diet item	Ca[a] (%)	P[a] (%)	Cu[a] (mg/kg)	K[a] (%)	Zn[a] (mg/kg)	β-CAR[b] (mg/kg)	T-TOC[b] (mg/kg)
Gruel[d]	1.63	1.03	1.5	0.52	37.0	16.4	17.8
Apple	0.05	0.05	2.6	0.72	2.3	—	—
Sugar cane	0.08	0.02	20.0	0.63	10.0	1.93	6.96
Golden bamboo							
Culm	0.14	0.20	15.0	1.10	24.0	3.31	8.26
Branch	0.17	0.33	18.0	1.0	50.0	7.77	11.71
Leaf	0.73	0.31	13.0	1.0	24.0	32.2	17.2
Shoots	0.27	0.44	35.0	2.33	45.0	—	—
Umbrella bamboo							
Culm bark	0.23	0.13	18.0	0.29	23.0	8.07	10.1
Culm pith	0.25	0.27	17.0	0.78	21.0	5.54	4.9
Branch	0.29	0.42	20.0	0.91	90.0	7.75	4.43
Leaf	0.47	0.47	20.0	1.20	55.5	66.2	22.2
Drinking water[c]	Trace	Trace	<0.001	Trace	—	—	—

[a] Crossfield Laboratories, Crossfield, Alberta.
[b] Norwest Labs, Edmonton, Alberta.
[c] City of Calgary, Engineering.
[d] Without cod liver oil, vitamin E supplement.

T-TOC compared to other diet items; leaves of both bamboo species had higher Ca and vitamin levels compared to other parts of the plant. Sugar cane and bamboo contained 10× the Cu levels seen in gruel or apples. Levels of Ca and P were higher in gruel than in other diet items. The mean Ca:P ratio for the bamboo plant was 1.07:1 although the only plant parts with a Ca:P ratio >1 were leaves and umbrella bamboo bark. Potassium concentration was high in golden bamboo shoots; Zn levels were similar in all diet items except apples. Drinking water contributed negligible amounts of minerals.

Bamboo provided 55% of the dry matter (DM) of the diet yet contributed 25% of dietary Ca, 83% of dietary Cu, 80% of dietary K, 28% of dietary P, 64% of dietary Zn, 62% of dietary B-CAR, and 15% of dietary T-TOC.

The total diet consumed by the pandas in this study provided the following levels of nutrients (mean values) on a DM basis; 0.82% Ca, 0.62% P, 1.05% K, 14.3 mg/kg Cu, 31.8 mg/kg Zn, 12.2 mg/kg B-CAR, and 12 mg/kg T-TOC. These values are compared with established nutrient requirements of a monogastric carnivore (dog) in Table 2.

Additionally, serum concentrations of these nutrients (n = 1 animal) are found in Table 2 and compared with values reported for another herbivorous ursid.

Mineral levels in bamboo in this study were compared to data obtained from bamboo in the Wolong Natural Reserve (Schaller et al., 1985). In those studies, *Sinarundinaria* sp. and *Fargesia* sp. in Wolong contained Ca levels of 0.01 to 1.0% DM with an increased level in leaves compared to other plant parts. Phosphorus levels were 0.5 to 1.0%. Potassium and Zn levels were measured between 0.001 to 0.01% and Cu concentration was found to be at a low level of 0.0001%. Lower concentrations of minerals were seen in older plant parts. Bamboo in this study had similar levels of Ca and Zn compared to Wolong bamboo. However, Cu and K levels were higher in the study bamboo and P levels were lower. Bamboo fed during the panda loan was obtained from a nursery in San Diego (Evergreen Distributers Inc., Escondido, California 92025, USA) which used fertilizers/micronutrients containing

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TABLE 2. Dietary concentrations (DM basis) and serum (n = 1) levels of vitamins and minerals for two giant pandas with comparison to domestic dog dietary requirements and spectacled bear plasma levels.

	Ca (%)	P (%)	K (%)	Cu (mg/kg)	Zn (mg/kg)	B-CAR (mg/kg)	T-TOC (mg/kg)
Diet							
Canine requirements[a]	0.59	0.44	0.4	2.9	35.6		
2.5-yr-old panda	0.68	0.47	1.03	14.0	32.7	12.7	12.1
4.5-yr-old panda	0.96	0.76	1.07	14.5	30.9	11.6	11.8
						RET	A-TOC
Serum							
4.5-yr-old panda serum µg/ml	99.0	68.0	46.0	1.29	1.14	0.56	14.8
Spectacled bear[b] plasma (µg/ml)	92.5 ± 1.2			0.7 ± 0.1	1.4 ± 0.1	0.20 ± 0.03	18.6 ± 2.98

[a] National Research Council, 1985.
[b] Dierenfeld, E. S.

Cu and K and this may explain the increased levels of these minerals in study bamboo as compared to bamboo from China.

Seasonal variation in mineral levels was seen in Wolong bamboo with a marked decline in September (Schaller et al., 1985). The present study was conducted during late spring/early summer. Variation between various plant parts was seen in Wolong with leaves generally having higher concentrations of all minerals. This is similar to our results showing some variation in the mineral concentration of various bamboo plant parts with leaves having greater Ca and fat-soluble vitamin concentrations than other bamboo plant parts.

Several studies have shown panda feeding preferences for leaves over other parts of bamboo plants (Dierenfeld et al., 1982; Schaller et al., 1985; Mainka et al., 1989), and in this case resulted in an increased intake of some minerals and fat-soluble vitamins.

Compared to domestic canid requirements, giant panda dietary intake levels of Ca, Cu, K, P and fat-soluble vitamins were higher, while dietary Zn intake was low (Table 2) (National Research Council, 1985). However, it should be noted that this panda data represents total intake whereas NRC data are based on "available nutrients."

Intake of Cu in this study (14.3 mg/kg) may have been greater than intake by free-ranging pandas but was still well below reported toxicity levels for Cu in other nonruminant species including rats and swine—250 mg/kg (Rechcigl, 1978). Also, in native panda habitat the main water source was found to contain higher than average levels of minerals (Schaller et al., 1985) which may have increased daily mineral intake by wild pandas. The water supply in Calgary contained negligible levels of measured minerals and would likely not contribute substantially to dietary intake.

Although no information is available on normal values of vitamins and minerals in

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the blood of giant pandas, the vitamin values which were seen in this study are similar to levels detected in another herbivorous bear species, the spectacled bear (Table 2) (Dierenfeld, 1988). Serum Cu and RET levels were higher in pandas while serum A-TOC levels were lower.

During the course of the loan, the animals appeared to be in good condition and actually grew and/or gained weight during the visit. The younger panda gained 25 kg and the older animal gained 12 kg (Mainka et al., 1989). It would appear the supplied diet was adequate for maintenance and growth requirements.

This report concerns results seen in diets of only two pandas and only one serum sample. More research needs to be conducted to determine the importance of minerals and fat soluble vitamins in panda nutrition.

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