OBSERVATIONS OF GROWTH OF SOUTH AFRICAN CHEETAHS (*ACINONYX JUBATUS JUBATUS*) FED DIFFERENT CARNIVORE DIETS

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Abstract

Significant changes have occurred in the availability of raw ingredients used in fresh meat-based carnivore diets, and as a result, the finished diets. Two litters (n = 9) of maternally reared South African cheetahs (*Acinonyx jubatus jubatus*) included in this retrospective study of cub growth were offered comparable carnivore diets that differed primarily in the species (horse [Diet A, Litter 1], cattle [Diet B, Litter 2]) source of the principle ingredients. Both litters were weaned from Diet A to Diet B during the scope of the study, but at different days of age. There was no statistically significant difference in average daily gain between weeks 6 and 74 (95.6 g d^{-1} and 96.9 g d^{-1} for Litters 1 and 2, respectively) ($P > 0.05$). National restrictions in the availability of the United States Department of Agriculture (USDA) inspected horsemeat necessitate the consideration of readily available, domestic sources of meat ingredients from alternative species as ingredients for fresh meat-based carnivore diets. The results of this study add to the body of objective studies that support the use of beef as part of scientifically formulated, properly handled and hygienically produced fresh meat-based diets for carnivorous species.

Introduction

Over the past decade, there have been significant changes in availability of fresh meat ingredients used as primary components of raw meat-based carnivore diets in the United States. These changes have been influenced by two noteworthy factors: the industry requirement for meat ingredients to originate from animals that are inspected, and harvested ingredients handled in accordance with the United States Department of Agriculture (USDA) guidelines; and the reduction in meat ingredients that comply with these USDA guidelines that have been harvested from horses. To maintain the quality standards for these highly perishable ingredients, users of raw meat-based carnivore diets have moved to beef-based diets, a readily available source of mammalian muscle ingredients, or elected to import diets composed of other species from international sources.

Animal disease and health concerns have further complicated the movement of uncooked meat products over international borders, necessitating acquisition of permits, inspections and other logistics that complicate the shipment of a highly perishable food product.

Based on these issues, the Smithsonian National Zoological Park made the decision to discontinue the use of all raw meat-based carnivore diets based on horsemeat, and transition animals eating those diets to a nutritionally comparable diet based on beef.

South African cheetahs (*Acinonyx jubatus jubatus*) were one of several species involved in the transition. At the time of the transition, the collection included reproductively active adults, lactating females, geriatric adults and growing juveniles. This study focuses on the growth of those juveniles during the transition between the horsemeat and beef-based carnivore diets.

Methods

Two litters of maternally reared South African cheetahs were included in this retrospective study. One litter (Litter 1) included 2 females and 2 males born on 23-Nov-2004 (day (d) 0). The second (Litter 2), 3 females and 2 males, were born on 14-Apr-2005 (d 0). Each litter was the first parity for the respective dam. Initial body weights for all neonates were recorded on d 28. Subsequent weights were recorded every 7-14 days as part of routine husbandry. All cubs survived beyond weaning. Statistics regarding each litter are summarized in Table 1.

Both adult females were offered a fresh, nutritionally complete horsemeat-based carnivore diet (Diet A: Carnivore 90/10, Dallas Crown, Inc.®, Kaufman TX 75142) prior to, and immediately following parturition.

On d 140 and 113, Litters 1 and 2, respectively, were prescribed diets that were group fed while the cubs were isolated from the dam. The initial diet offered to each litter was the same horsemeat-based carnivore diet offered to the dams (Table 1; Carnivore 90/10, Dallas Crown, Inc.®, Kaufman TX 75142).

Twenty-four days (d 137) following the presentation of food amounts specifically for the Litter 2 cubs, a step-wise transition was initiated for both the dam and cubs to replace the horsemeat-based carnivore diet with a fresh, nutritionally complete beef-based diet for carnivores (Table 1; Natural Balance® Zoo Carnivore Diet 10; Dick Van Patten's Natural Balance Pet Foods, Inc., Zoological Division, Pacoima, CA 91331). The transition between the two carnivore diets was completed for these subjects on d 193.

The same transition from horsemeat to beef-based carnivore diet was initiated on d 279, and completed on d 335, for Litter 1.

On d 183, Litter 2 cubs were no longer housed with the dam. Beginning on d 236, the Litter 2 cubs were individually fed.

The body condition of the dam of Litter 1 was evaluated as body condition score (BCS) 5 based on physical examination. The pre-fasting mass of this animal was 44 kg. The body condition of the dam of Litter 2 was evaluated based on visual examination as BCS 5. The body mass of this animal was 44.5 kg seven days prior to body condition assessment. Body condition scores were evaluated using a 1-9 body condition scoring system. Based on these observations, an adult mass of 44.25 kg is used in relevant calculations.

Diets A and B were analyzed for energy, proximate, fiber, and selected nutrients as part of the Smithsonian National Zoological Park's routine quality control program. A paired t-test was used to compare weekly average gain between both litters between weeks 6 and 74.[6]

Results and Discussion

Litter 1 and 2 cubs were first observed eating solids (horsemeat-based carnivore diet) on d 33 and d 37, respectively. Litter 1 and 2 cubs were last observed nursing from their dam on d 147 and d 124, respectively.

A decline in weight gain, and eventual weight loss was observed across all individuals in Litter 1 on d 260, d 265, and d 272. This deviation from anticipated growth rate occurred while the animals were being group fed; separate from the dam, the horsemeat-based carnivore diet. Although not apparent, it is possible that the stresses and other factors associated with cubs isolation from the dam could have contributed to these weight deviations. Weight gain resumed to levels that were considered normal beginning on d 279, which was the same time that the transition from the horsemeat to beef-based carnivore diet was initiated.

Weight changes in both litters from d 28 to d 525 are presented in Figure 1.

Average daily gain d 28 to d 150 (weaning); d 150 (weaning) to d 280; d 280 to d 525 are presented in Table 3. When calculated as a weekly mean of average daily gain between weeks 6 and 74, the rate of growth was 95.6 g d^{-1} and 96.9 g d^{-1} for Litters 1 and 2, respectively. There was no statistically significant difference in average daily gain between Litter 1 and Litter 2 ($P > 0.05$).

The average daily gain of fissiped carnivores can be calculated using the formula:

$$Y = 0.0543W^{0.70}$$

where W is the weight of the adult animal in grams and Y is the average daily gain in grams.[2,7] Using this formula in conjunction with the average weight of the adult females determined in association with assessment of optimal body condition mentioned above, the average daily gain of the litters would be predicted as:

$$Y = 0.0543(44250)^{0.70} = 0.0543(1787.1) = 97.0 \text{ g d}^{-1}$$

This predicted value is comparable to the actual growth rates (95.6 g d^{-1} and 96.9 g d^{-1}) observed across both litters.

Actual analysis of the two carnivore diets is presented in Table 2. Diet A (horsemeat) crude fat concentrations were below those guaranteed by the manufacturer. This lower concentration of fat results in an overall lower energy density in Diet A. Although intake data was not analyzed as part of this retrospective study, it is possible that the lower energy density of the diet, without a subsequent increase in total diet consumed, could contribute to the numerically lower average daily gain observed in Litter 1.

The beef-based carnivore diet was initially formulated based on regional requirements for the use of beef as an alternative to horsemeat as the primary component for a diet using USDA inspected ingredients.[1] The beef-based formulation has been tested and shown to be effective with a

variety of carnivorous species at multiple stages of life.[4,5] Those regional restrictions have now expanded to a national level, further necessitating the need to consider readily available, domestic sources of alternative USDA inspected ingredients for fresh meat-based carnivore diets.[3]

This retrospective study is yet another example of the successful application of beef-based carnivore diets. Although the transitions from mother's milk to both formulations complicate this analysis, the absence of differences between growth of the two litters supports the nutritional adequacy of both formulations. This is not surprising, as both formulations originated from the same industry effort, despite the differences in the species origin of skeletal and cardiac muscle.[1]

The authors are hopeful that this reference information will be useful for other animal caretakers that manage this species, are monitoring juvenile growth or implement similar changes in carnivore diets.

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Table 1. Reproductive status and age of adult female South African cheetahs (*Acinonyx jubatus jubatus*) and initial average body weights ± standard deviation of cubs of each litter.

	Litter 1	n	Litter 2	n
Dam parity	0		0	
Age of dam at birth	4 years, 7 months		3 years, 11 months	
Cub bodyweight, kg, day 28				
litter	1.6 ± 0.1	4	1.6 ± 0.1	5
females	1.6 ± 0.1	2	1.6 ± 0.1	3
males	1.5 ± 0.0	2	1.6 ± 0.2	2

Table 2. Selected nutrient analysis of two fresh meat-based carnivore diets (all nutrients expressed on dry-matter basis, except moisture).

	Diet A[1]	Diet B[2]
Dry matter, %	33.9	33.6
Gross energy, kcal g^{-1}	5.90	6.16
Crude protein, %	55.1	49.0
Crude fat, %	8.6	10.4
Acid detergent fiber, %	1.73	2.59
Ash, %	2.4	2.7
Calcium, %	1.29	1.63
Phosphorus, %	0.37	0.37
Iron, ppm	155	256
Zinc, ppm	70	70

[1]Diet A = Carnivore 90/10 (Dallas Crown, Inc., Kaufman TX 75142; http//www.dallascrown.com);
[2]Diet B = Zoo Carnivore Diet 10 (Natural Balance® Zoo Carnivore Diet 5; Dick Van Patten's Natural Balance Pet Foods, Inc., Zoological Division, Pacoima, CA 91331; http://www.naturalbalanceinc.com).

Table 3. Average daily gain (ADG, g d^{-1}) during specific periods post-partum and general diets offered during those periods for two maternally reared litters of South African cheetahs (*Acinonyx j. jubatus*).

	Litter 1		Litter 2	
	ADG, g d^{-1}	diet	ADG, g d^{-1}	diet
days 28-150	81.5	maternal milk with access to horsemeat-based carnivore diet[1]	93.5	maternal milk with access to horsemeat-based carnivore diet[1]
days 150-280	118.2	horsemeat-based carnivore diet	127.0	horsemeat-, and beef-based carnivore diets[2]
days 280-525	75.4	horsemeat, and beef-based carnivore diets[3]	57.5	beef-based carnivore diet
days 28-525	89.7	mixed	84.7	mixed

[1]Litter 1 and 2 cubs first observed eating carnivore diet on days 33 and 37, respectively. Litter 1 and 2 cubs were last observed nursing from their dam on days 147 and 124, respectively.
[2]Step-wise transition to replace the horsemeat-based carnivore diet with a fresh, beef-based diet for carnivores initiated on day 137 and completed on day 193.
[3]Step-wise transition to replace the horsemeat-based carnivore diet with a fresh, beef-based diet for carnivores initiated on day279 and completed on day 335.

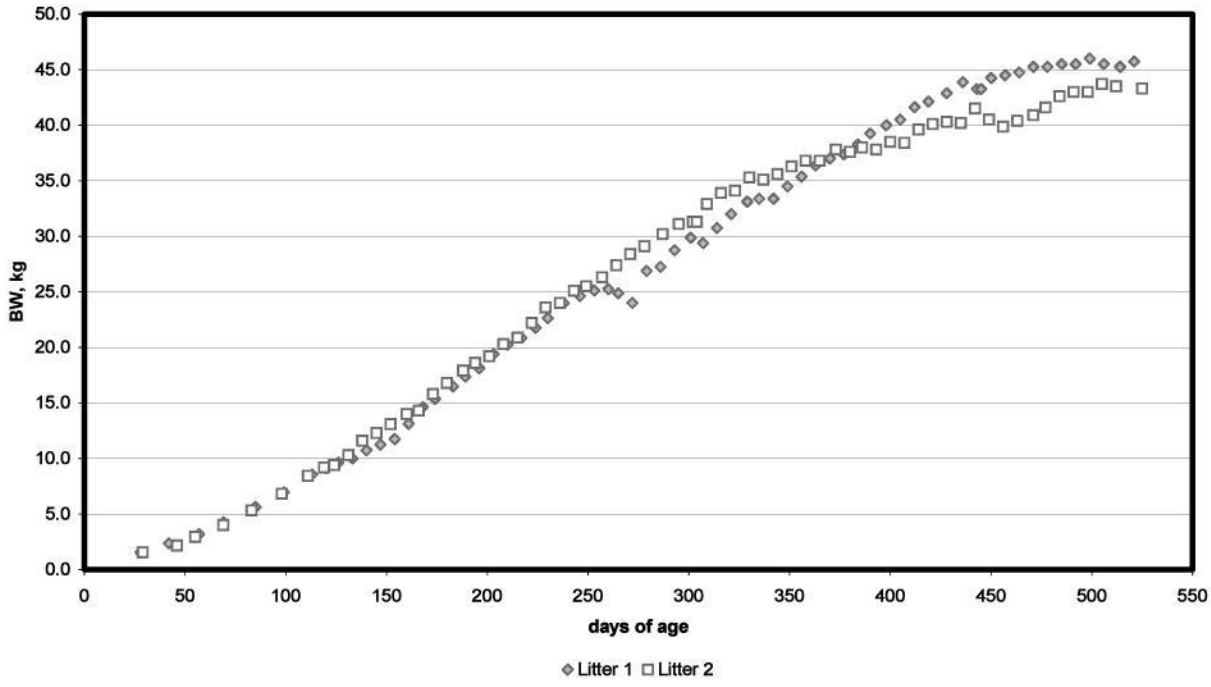

Figure 1. Growth of two litters of South African cheetahs (*Acinonyx jubatus jubatus*).