

# Seasonal changes in digestion in black bears

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## Introduction

Winter dormancy in black bears (*Ursus americanus*) is likely an adaptation to predictable seasonal food shortages. Additionally, embryo development and parturition in bears are physiologically linked to hibernation (Herrero 1978). Fat is the major source of calories during hibernation and bears may lose as much as 25% of their body weight during the winter while maintaining lean body mass (Nelson et al. 1973). Thus, the ability to increase fat reserves before denning is necessary for winter survival and successful reproduction. Fat storage occurs during the fall (the "hyperphagia stage" of Nelson et al. (1983)), and many field studies have documented pronounced seasonal shifts in the diets of free-ranging bears (e.g., Tisch 1961; Hatler 1972; Beeman and Pelton 1980; Eagle and Pelton 1983; Grenfell and Brody 1983). Dietary shifts track plant phenology, and generally involve a transition from green forage and soft mast during spring and summer to hard mast in the fall.

Despite a strong dietary dependence on vegetable matter, bears exhibit only minor dental adaptation to herbivory and have retained the short, unspecialized gut of their carnivorous ancestors. Bunnell and Hamilton (1983) suggest that in grizzly bears (*Ursus arctos*) the evolution of a few morphological adaptations to herbivory combined with the conservation of physiological adaptations to carnivory make possible the rapid weight gains that occur before denning. They assume an evolutionary trade-off between the ability to digest food

rapidly (a trait of carnivores) and the ability to digest low quality food efficiently (a trait of herbivores), and conclude that, in grizzlies, rapid processing at the expense of efficient digestion of fiber allows bears to take advantage of the large amounts of food available during the foraging period. Their experiments demonstrated that the digestive efficiencies of grizzlies are not markedly different from those of obligate carnivores. This note describes an effort to determine the digestive abilities of black bears, and to determine any seasonal differences in those abilities.

## Methods

Six adult bears, ranging from 91 to 178 kg (mean weight = 63.4 kg, SD = 28.6 kg) at the Ober-Gatlinburg Black Bear Habitat in Gatlinburg, Tennessee, were used in digestion trials in August and November 1983. The bears were housed in three enclosures, each holding one male and one female. The normal ration for the bears consisted of dry dog food (Tennessee Farmers Cooperative, Laverne, TN 37086, U.S.A.), fed *ad libitum*, supplemented by produce discarded by local grocers. For the trials, all produce was withheld and the dog food ration was reduced to approximately 95% of *ad libitum* consumption for 7 days; portions of three feces in each enclosure were collected on the 7th day.

Fecal and ration samples were frozen until laboratory analysis was performed, at which time the samples from each enclosure in each trial were thawed and dried at 101°C. three subsamples were drawn from the fecal samples from each enclosure. Crude protein content was estimated by the macro-Kjeldahl technique (Association of Official Analytical Chemists 1970) (three replicates per subsample). Gross energy was estimated in an adiabatic oxygen bomb calorimeter (Parr Instrument Company, Moline, IL 61265, U.S.A.) (two replicates per subsample). Acid-insoluble ash content was estimated by the method of Van Soest (1966) (three replicates per subsample).

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TABLE 1. Composition of experimental diets and fecal samples from bears, on a dry-weight basis

	Crude protein (%)	Gross energy (kJ/g)	Acid-insoluble ash (%)
This study			
Dog food ration			
August trial	36.7	19.292	1.12
November trial	30.9	19.212	1.22
Fecal samples*			
August mean ( <i>n</i> = 9)	20.4 (0.60)	17.403 (1.333)	2.58 (0.002)
November mean ( <i>n</i> = 9)	19.3 (0.76)	15.038 (0.063)	2.72 (0.001)
Grizzly rations used by Bunnell and Hamilton (1983)			
Basal ration	36.3	5577	0.11
Basal and beet pulp	21.2	4729	1.42

\*SE given in parentheses.

TABLE 2. Apparent digestibilities in bears

	Approximate consumption*	Apparent digestibility coefficients†	
		Crude protein	Gross energy
August trial			
Enclosure 1	4.4 (0.33)	0.765	0.645
Enclosure 2	3.3 (0.24)	0.745	0.626
Enclosure 3	2.5 (0.41)	0.764	0.645
August mean	3.4 (0.70)	0.758 (0.0113)	0.638 (0.0110)
November trial			
Enclosure 1	7.5 (0.45)	0.729	0.651
Enclosure 2	5.0 (0.34)	0.708	0.640
Enclosure 3	7.0 (0.21)	0.723	0.656
November mean	6.6 (1.12)	0.720 (0.0108)	0.649 (0.0082)
Grizzlies on basal and beet ration (Bunnell and Hamilton 1983)‡		0.751	0.620

\*Amount provided - orts, in kg/day for each enclosure. SD given in parentheses.

†SE given in parentheses.

‡Mean values for two bears.

Apparent digestibilities of crude protein and gross energy were estimated using the indicator method (McCarthy et al. 1974; Bunnell and Hamilton 1983), with acid-insoluble ash serving as the indicator:

$$\text{apparent digestion coefficient} = 1 - \frac{(\text{AIA in feed}) \times (Y \text{ in feces})}{(\text{AIA in feces}) \times (Y \text{ in feed})}$$

where AIA is the dry weight proportion of acid-insoluble ash and *Y* is the dry weight energy content or proportion of crude nitrogen.

### Results and discussion

The dog food ration used in this study was substantially higher in crude protein than the natural food plants normally eaten by black bears, which typically contain 2–19% crude protein (Mealey 1975; Eagle and Pelton 1983). Composition of the ration used in this study (Table 1) was most similar to the "basal and beet pulp" ration used by Bunnell and Hamilton (1983) and the apparent digestibilities (Table 2) were correspondingly similar.

Digestibility of crude protein decreased (paired *t*-test, *t* = 26.41, *P* = 0.0014) while the digestibility of gross energy increased (paired *t*-test, *t* = 4.58, *P* = 0.0445) from August to

November. Increased food consumption in November implies an increased transit rate which in turn could have caused the decrease in apparent protein digestion (Castle and Castle 1956; Rerat 1978). If transit rate were the only factor affecting seasonal changes in digestibility, however, a simultaneous decrease in apparent gross energy digestion would be expected. Instead, we found an increase in apparent energy digestion, indicating that bears were selectively digesting and (or) absorbing carbohydrates and fats at the expense of protein.

Inhibition of amino acid absorption by carbohydrates has been well documented in several monogastric animals (Alvarado 1971), but there is little evidence that the degree of inhibition is controlled by factors other than concentrations of specific substrates in the gut. This mechanism could operate in the wild, where summer foods are typically much higher in protein than fall foods (Eagle and Pelton 1983), but cannot explain our experimental results because rations in both trials were similar. We suggest that a systemically, possibly hormonally, mediated increase in carbohydrate and fat assimilation and decrease in protein assimilation occurs during the predenning hyperphagic period. If lean body growth ceases in the fall, as data from Nelson et al. (1983) imply, protein

(continued)

requirements would be reduced and preferential assimilation of dietary substrates most efficiently converted to fat would appear to be adaptive.

This type of hormonal control of assimilation has yet to be documented, but would be consistent with the array of physiological adaptations, particularly those of nitrogen metabolism (Nelson et al. 1973, 1975, 1983), already described in bears.

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