SEASONAL NUTRITION OF BLACK BEARS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

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Abstract: We sampled 86 composites of 646 scats collected at 2-week intervals during 1976 and 1977 and identified 5 seasonal patterns of food use by black bear (*Ursus americanus*) in the Great Smoky Mountains National Park. Plant material composed 80% of the diet, and animal remains, mostly insects, were 12%. Major plant food items were identified. Crude protein and acid-detergent-fiber content of major food items were determined and nutritional value of each seasonal diet was evaluated. The early spring diet was of low nutritional value and bears lost weight during spring. The late spring, summer, and early fall diets were conducive to growth of bears because readily available energy and high-quality proteins were consumed. The late fall diet, high in available energy, led to rapid increase in weights of bears.

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Beeman and Pelton (1980) reported seasonal food habits of black bears in the Smoky Mountains. Although that study was based on a large sample of scats and stomach contents, we believed it did not give an accurate representation of bears throughout the Great Smoky Mountains National Park (GSMNP). In the Beeman and Pelton study many scats were collected from picnic areas and campgrounds or were from a former garbage dump; therefore, that effort involved a large sample from a small cohort (5% of the population, Pelton and Burghardt 1976) that did not avoid contact with humans.

Analyses of food habits are of limited use unless we know the nutritive value of individual food items and of seasonal diets. Several authors (Wainio and Forbes 1941, King and McClure 1944, Beck and Beck 1955, Burns and Viers 1973, Landers et al. 1979) evaluated nutritional value of various food items typically consumed by black bears. Beeman and Pelton (1980) reviewed several nutrition studies and found most food items high in carbohydrates and low in protein. Nutritive value of seasonal diets, however, was not evaluated. We designed the present study to provide a sample of scats representing most of the study area. Specific objectives were to describe the seasonal diets of bears in the GSMNP and evaluate the nutritional quality of their seasonal diets.

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STUDY AREA

GSMNP encompasses 2,072 km^2 in eastern Tennessee and western North Carolina; it is part of the Unaka Mountains of the Blue Ridge Province in the southern division of the Appalachian Highlands (Fenneman 1938). The study area included portions of GSMNP in Tennessee west of U.S. Hwy. 441 (Fig. 1). Most of the study area was accessible only by foot trails due to steep slopes (> 10%) and park regulations limiting vehicle access.

Annual precipitation averages 140 cm at lower elevations; precipitation generally exceeds evapotranspiration during all seasons (Shanks 1954). Average annual temperature is 14 C at lower elevations and decreases slightly with increasing elevation (Tanner 1963). GSMNP supports dense and highly diverse vegetation with much interspersion of forest types.

METHODS AND MATERIALS

We established 5 routes of scat collection, each within a separate section of the study area (Fig. 1). Routes were hiked biweekly and scats collected (May to September 1976, May to mid-

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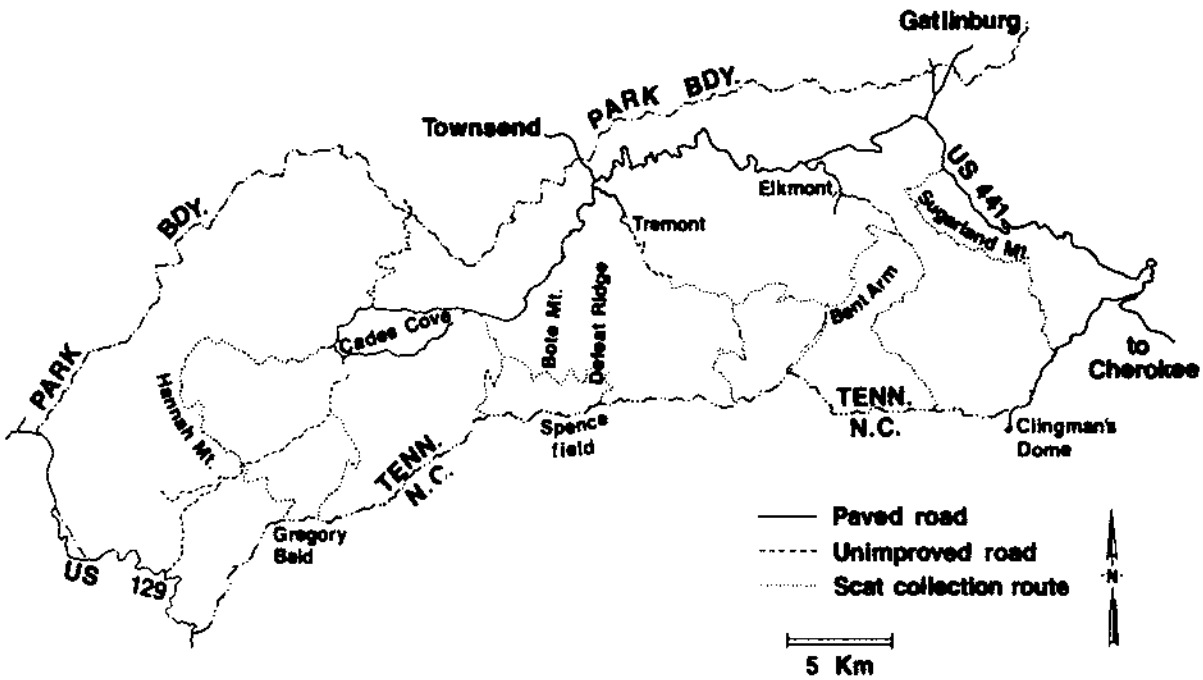

Fig. 1. Study area and routes of scat collection within the GSMNP.

October 1977). Freshly deposited scats were collected when found during field work for other projects. Scats were sampled, and the samples combined by section and date of collection (composite scat). Composite scats were washed through 2 sieve screens (mesh size 2.00 and 0.42 mm) and air dried or placed in a drying oven at 60 C for 48 to 72 hr.

For sampling, fecal material from a composite was sprinkled over a grid of 100 quadrats (each quadrat measured 2×2 cm). We identified material in 10 randomly chosen quadrats to the lowest taxon possible and recorded the presence of individual items in each quadrat. Fecal material on the grid was then replaced in the composite and the procedure repeated. Initially 100 quadrats were examined per composite. Results, however, were similar for 50 and 100 quadrat samples (Wilcoxon signed rank test, $P > 0.1$, Gibbons 1976), and we subsequently used 50 quadrats.

The relative percent density (RD) of food items identified was calculated for each composite (Hansen 1975). We determined percent frequency (F) of a given food item in each composite and used F to calculate density (D) of each food item in the composite:

$$F = 100\,(1-e^{-D})$$

where e is the base of natural logarithms. We then used D to calculate RD for all food items identified in each composite:

$$RD = \frac{D \text{ of each item}}{D \text{ for all items}} \times 100$$

After calculating RD for food items in all composites, we computed the composition of scats throughout the study area for each 2-week interval to determine major food items. Major food items were those that comprised over 5% of fecal remains for at least 1 2-week period in each year of the study. Results of scat analyses were examined for patterns.

Samples of squawroot (*Conopholis americana*), blackberry (*Rubus* sp.), huckleberry (*Gaylussacia* sp.), blueberry (*Vaccinium* sp.), and chestnut oak acorns (*Quercus prinus*) were dried and analyzed for crude protein (Crampton and Harris 1969:42) and acid-detergent fiber (ADF) (Van Soest 1966). Ash, ether extract, and nitrogen-free extract were not determined. For plant material the figure for crude ash usually has little direct nutritional use because the ash component in plants is

Table 1. Relative percent density (RD) of major food items in biweekly composite scats of black bears in the GSMNP, 1976.

	2-week interval ending										
	Apr	May	Jun		Jul		Aug			Sep	Total
Food item	26(6)[a]	10(11)	7(38)	21(35)	19(13)	2(54)	16(55)	30(40)	13(49)	27(25)	(335)
Grass and herb. matl.	92	95	78	48	24	24	8	3	6	2	38
Squawroot			12	32	36	11	9	5	3		11
Blackberry					1	30	19	49	1	13	11
Huckleberry				6	7	11	28	10	19	1	8
Blueberry				3	3	5	3	6	4	2	3
Black Cherry								Tr[b]	11	34	5
Fire Cherry						3	3	1	1		1
Sassafras						1	Tr	4	12	7	2
Oak acorns								Tr	6	13	2
Insect	1	1	2	7	19	8	19	15	23	19	11
Mammal			5		6	4	1	Tr		2	2
Debris	7	4	2	4	4	3	9	7	11	9	6
Garbage			1	Tr		Tr	1				Tr

[a] Number in parentheses is number of scats in the sample.
[b] Tr = Trace.

highly variable in the total amount and component parts; many plants are high in silica, an element of no nutritional value (Crampton and Harris 1969:51). Also, most food items typically consumed by bears are low (< 5%) in ash (Wainio and Forbes 1941, Landers et al. 1979). Ether extract and nitrogen-free extract are generally readily available sources of nonspecific energy (Crampton and Harris 1969:35, 47).

The protein content of a feed may be an indirect measure of its digestible energy because protein is usually highly digestible (Crampton and Harris 1969:48). A food with a high ADF content, a measure of the level of cellulose, may be regarded as relatively undigestible because bears lack a cecum and their simple stomach is too acid to support the microbes necessary for the digestion of cellulose (Rogers 1976).

RESULTS

Seasonal Food Habits

Plant material composed over 80% of remains in bear scats from GSMNP, and animal material, mainly insects, was 12%. Other materials consumed were debris (including leaf fragments, twigs, rock chips, and wood fragments) and garbage (any item of artificial food). Garbage was not a major food item but was included in Tables 1 and 2 because management implications may be related to its use.

Table 2. Relative percent density (RD) of major food items in the biweekly composite scats of black bears in the GSMNP, 1977.

	2-week interval ending											
	May		Jun		Jul			Aug		Sep		Oct	Total
Food item	9(20)[a]	26(27)	6(22)	20(35)	4(29)	18(40)	1(33)	15(34)	29(21)	12(13)	26(28)	10(9)	(311)
Grass and herb. matl.	90	74	45	26	15	4	7	9	18	5	12	4	26
Squawroot		14	2	17	16	11	1						5
Serviceberry			19	27	9	9	3	1					6
Blackberry					11	35	48	23	1				10
Huckleberry			8	20	15	19	24	7					8
Blueberry			1	1	3	2	16	2	1				3
Black Cherry								6	5				1
Fire Cherry							Tr[b]	6					Tr
Sassafras							2						Tr
Oak acorns									8	65	63	78	18
Insect	1	5	17	8	12	6	4	7	11	9	11	6	8
Mammal	8		Tr	4	4	5	7		8				3
Debris	1	5	14	9	12	12	6	13	22	12	14	6	10
Garbage					Tr		Tr						Tr

[a] Number in parentheses is number of scats in the sample.
[b] Tr = Trace.

We delineated 5 seasonal diets (early spring, late spring, summer, early fall, and late fall) based on the RD of food items in biweekly composite scats (Tables 1 and 2). The pattern of extensive use of vegetative food in early spring, and switching to fruit and hard mast when the latter became available, was consistent with other studies of bears in the southeastern United States (Beeman and Pelton 1980, Landers et al. 1979).

The diet in early spring (from the start of scat collection in April to early June 1976 or late May 1977) was almost entirely herbaceous material. Animal material and debris accounted for the remainder of the diet (Tables 1 and 2). Results from the early spring diet were based on fewer scats than for other seasonal diets. The low number of scats collected was attributed to a low level of activity by bears during early spring (Garshelis and Pelton 1980) as well as less research activity than in other seasons.

Squawroot and serviceberry (*Amelanchier laevis*) composed 30% of the diet in late spring (June and July 1976, late May to middle July 1977). In 1976 only squawroot was eaten, whereas there was an equal occurrence of squawroot and serviceberry in 1977 scats. Serviceberry appeared at a higher level than squawroot in 1977, but for a shorter period of time (Table 2). We noticed abundant serviceberry in 1977, but none in 1976, and availability of squawroot appeared similar both years. It therefore appeared that bears preferred serviceberry. Although it was not consumed both years, serviceberry was included as a major food item because bears fed heavily on this fruit in all sections of the study area in 1977.

In late spring the RD of herbaceous material decreased to 43%. Huckleberry and blueberry were consumed in 2 sections but were not available in most of the study area. The incidence of animal remains increased to 12%, reflecting a greater use of insects than during early spring.

In summer (August 1976, mid-July to mid-August 1977) the RD of squawroot and serviceberry was low (< 10%), and blackberry, huckleberry, and blueberry accounted for 60% of all food remains, although proportions of the 3 fruits varied among sections of the study area (Tables 1 and 2). Fire cherry (*Prunus pennsylvanica*) and sassafras (*Sassafras albidum*) appeared in scats late in the summer, but use of these was low (1% each). Insect and mammal remains were at levels similar to those in late spring scats.

The diet in early fall (September 1976, late August to mid-September 1977) included a wide variety of fruits; black cherry (*P. serotina*) was most important (19%), and the RD of sassafras and fire cherry increased to 7% and 3%, respectively. The RD of herbaceous material dropped to 12%, and a decrease in the use of blackberry, huckleberry, and blueberry was noted. Acorns were beginning to mature at lower elevations and were eaten in most sections of the study area, but were a substantial portion (28%) of scats in only 1 section. There was a slight increase in the consumption of insects and mammals.

The use of acorns characterized the diet in late fall (September to the end of scat collection 1977) which was delineated only in 1977. Comparable data were unavailable for 1976 because scat collection ended in late September, and the usual peak availability of acorns is middle October (Strickland 1972). Because the 1976 acorn crop was good (Tennessee Wildlife Resources Agency 1977), we probably would have detected a switch to acorns had scat collection continued through October. The RD of other plant material and animal material in scats was low during late fall.

Chemical Analysis of Food Items

Plant food items consumed by bears were generally low in protein and high in fiber (Table 3). Acorns were a notable exception, being low in both protein and fiber. Animal material was high in protein.

Herbaceous material was highest in protein content among plant food items, but was also high in fiber. Because our measures of protein and fiber were relative, an increase in the percentage of fiber from food item to scat indicated absorption of other nutrients. It appeared that black bears were able to extract protein from herbaceous material. Jonkel (1978) noted a similar ability in grizzly bears (*U. arctos*) and polar bears (*U. maritimus*). Because the appearance of scats composed mainly of herbaceous material indicated little digestion of green vegetation, we believed only few nutrients were available to bears from herbaceous sources.

Table 3. Crude protein and acid-detergent fiber (ADF) content of food items typically consumed by black bears and of associated scats.

Sample	Data source	Composition (% dry matter) Crude protein	ADF[a]	Other fractions[b]
Herbaceous material[c]	Mealey 1975	19	33	48
Scat	This study	11	40	49
Squawroot	This study	8	22	70
Scat	This study	7	57	36
Serviceberry	This study	10	23	67
Blackberry	This study	10	30	60
Scat	This study	13	54	33
Huckleberry	Landers et al. 1979	2	20	78
Blueberry	Landers et al. 1979	6	20	74
Huckleberry and blueberry	This study	3	22	75
Scat	This study	9	55	36
Cherry	Wainio and Forbes 1941	7	28	65
Acorns (kernel only)	This study	6	4	90
Scat	This study	11	9	80
Insect[d]	Beck and Beck 1955 Southwood 1973	43	20	37
Mammal[e]	Mealey 1975	79	2	19

[a] Sources other than this study reported crude fiber ADF approximated by crude fiber/0.75 (Chandler 1978).
[b] Other fractions = 100% − (Crude protein + ADF).
[c] Average of all herbaceous material analyzed.
[d] Average of all insects analyzed.
[e] Average of *Cervus canadensis* (lean tissue) and *Microtus* sp. (whole).

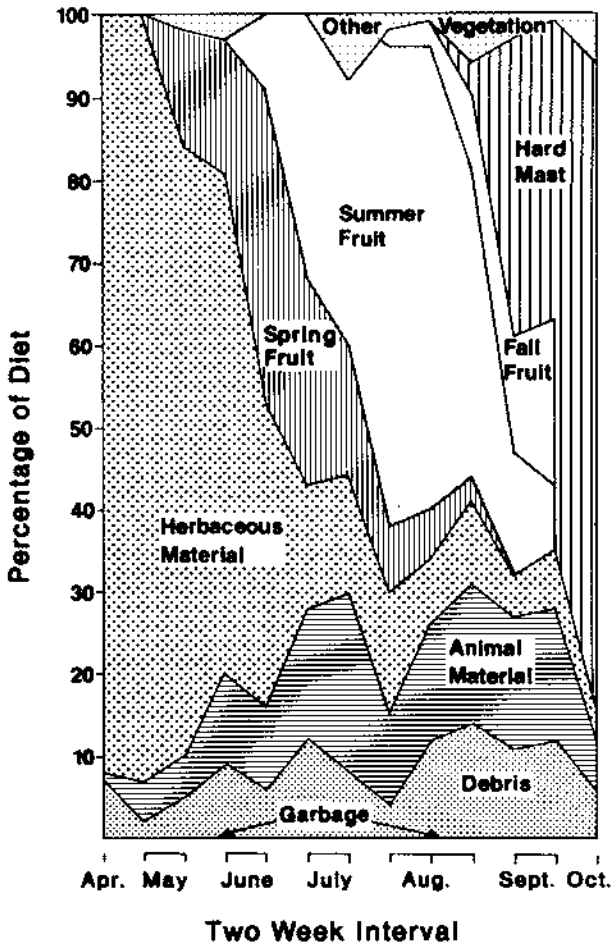

Fig. 2. Relative percent density (RD) of major food groups in scats of black bears in the GSMNP.

Squawroot probably was an important source of energy. Little protein was absorbed, and fiber was concentrated by digestion. The fruits (serviceberry, blackberry, huckleberry, blueberry, and cherry) were of similar nutritional value. All were low to moderate in protein content, moderate in ADF, and high in other fractions (particularly carbohydrates, Wainio and Forbes 1941). Sassafras fruit was not analyzed; we assumed it nutritionally similar to cherry. The protein in these fruits was unavailable to bears because most protein was located in seeds (Wainio and Forbes 1941), and bears did not crack or digest the seed coat. The absorption of carbohydrates was indicated by the decrease of other fractions from food item to scat (Table 3).

Among plant foods, acorns were exceptionally low in ADF and protein. Scats composed mainly of acorns also were low in these fractions. Acorns, however, were high in fats and carbohydrates (Wainio and Forbes 1941, Landers et al. 1979) and, therefore, were assumed highly digestible by bears.

Animal material was high in protein. Although insect and mammal remains occurred only in small quantities in all scat composites, animal material probably represented an important source of protein for black bears. As a monogastric species, black bears have a requirement for certain essential amino acids, and even a small quantity of animal material in the diet may meet this requirement (Crampton and Harris 1969:51).

Using nutritional values (Table 3) we divided plant food items into 3 broad classes: herbaceous material, fruit, and hard mast. We subdivided fruit into 3 categories according to season of primary use (Tables 1 and 2). We thereby established 6 food groups with similar nutritional values and concurrent use (Fig. 2). Herbaceous material included grass, green leaves, buds, forbs, and any other vegetative material encountered. Squawroot and serviceberry were grouped

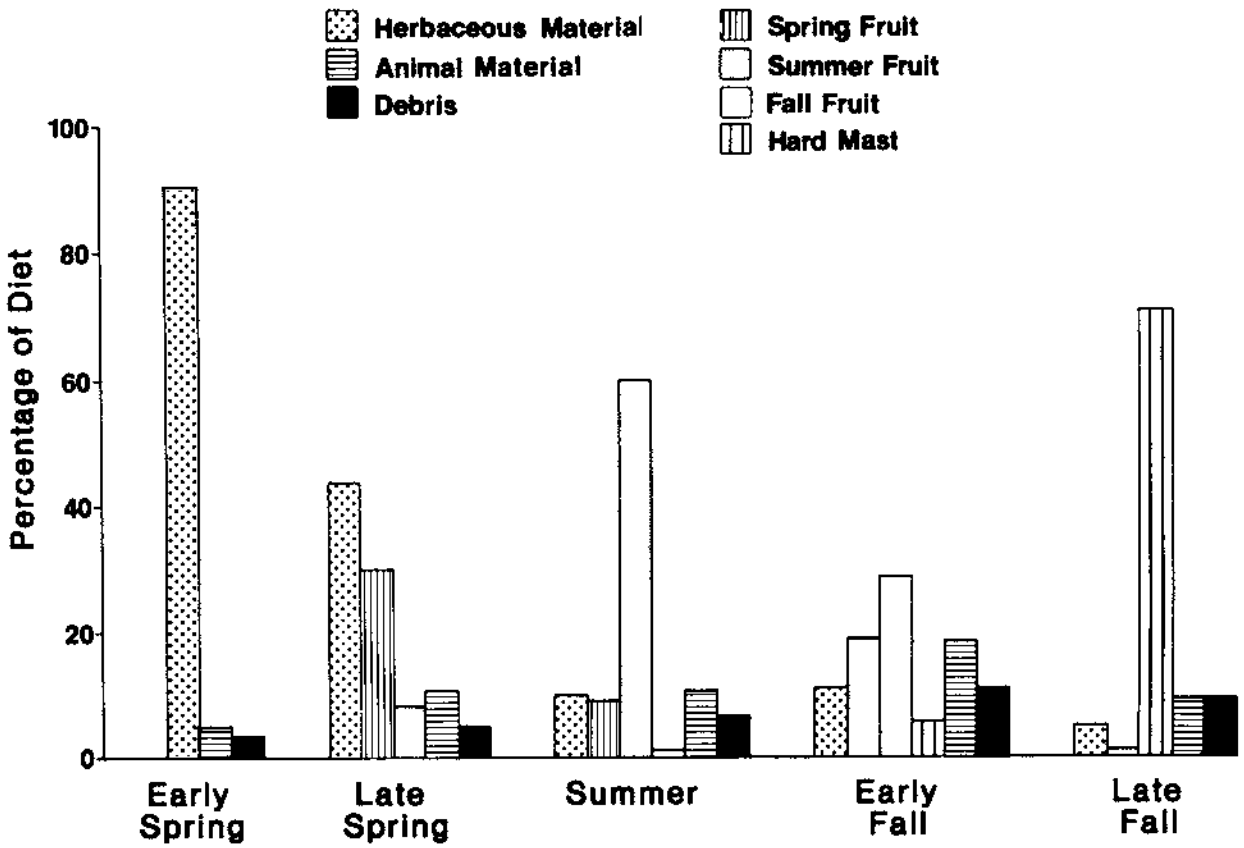

Fig. 3. Typical seasonal diets of black bears in the GSMNP.

as spring fruit; blackberry, huckleberry, and blueberry as summer fruit; and black cherry, fire cherry, and sassafras as fall fruit. Only acorns were identified as hard mast. Animal material included mostly insects and some mammal remains.

DISCUSSION

Black bears in GSMNP exhibited 5 seasonal patterns of food use (Fig. 3) representing 3 distinct levels of nutrition (Table 4). Early spring appeared to be a time of nutritional stress for bears. Diets were high in fiber, and thus generally undigestible by bears. As a result, bears in GSMNP lost weight during early spring (Beeman 1975:159). Bears showed similar response to nutritionally poor spring diets in Montana (Jonkel and Cowan 1971), Minnesota (Rogers 1976), and Washington (Poelker and Hartwell 1973). Poelker and Hartwell (1973:105) referred to this period of weight loss during the active period of early spring as a "negative foraging period."

Most bears in GSMNP exhibit only short periods of crepuscular activity during early spring, and a limited activity pattern may be a means of surviving a period of nutritional stress (Garshelis and Pelton 1980). Lactating females and growing cubs have protein and energy requirements greater than that for body maintenance, and the typical early spring diet may be

Table 4. Crude protein and acid-detergent fiber (ADF) content of seasonal diet of black bears in the GSMNP, 1976 and 1977.

	Composition (% dry matter)[a]	
Diet	Crude protein	ADF
Early spring	21	30
Late spring	17	25
Summer	13	23
Early fall	14	21
Late fall	10	8

[a] Relative percent density of food items in seasonal diets times proportion of crude protein or ADF in individual items.

inadequate to meet this increased requirement. A high level of activity by lactating females (Garshelis and Pelton 1980) probably reflects an increased foraging effort to meet the added protein requirement of lactation and growth.

Late spring, summer, and early fall were periods of similar nutritional levels (Table 4). Readily digestible food items were available and were consumed. Consumption of animal material increased, and insects became the major source of protein. Bears began gaining weight during late spring or summer (Beeman 1975), reflecting a response to a higher nutritional plane.

The late fall diet provided bears with readily available fats and carbohydrates, and therefore was a high-energy diet. Although it was still the major source of protein, animal material occurred only in small amounts in the late fall period. This low-protein diet fueled rapidly increasing bear weights (Beeman 1975), possibly reflecting increases only in body fat reserves.

The increase of body fat reserves instead of structural growth during late fall may be of important survival value to black bears by maximizing energy storage for the winter denning period and the negative foraging period of early spring. Lactating females and growing cubs may be exceptions. Lactation increases nutritional requirements or may draw upon body reserves if diets are insufficient to meet demands (Campbell and Lasley 1969:194). Female bears lactating the previous spring and summer may forage more than other bears to replace body reserves following lactation. Indeed, females with cubs exhibit the highest activity level of all cohorts of bears in GSMNP during the late fall period (Garshelis and Pelton 1980).

The above analysis illustrates different levels of nutrition available to black bears throughout the year and suggests bear responses to these levels of nutrition. Our knowledge of bear nutrition, however, remains at a state reached 30 years ago by deer researchers (Mautz 1978). Future food-related research should be directed in the areas of nutritional requirements and digestibility of food items by bears.

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