SEASONAL FOODS AND FEEDING ECOLOGY OF BLACK BEARS IN THE SMOKY MOUNTAINS

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Abstract: Between June 1969 and January 1972, 75 stomachs and 1,025 scats from black bears (*Ursus americanus*) were collected from the Great Smoky Mountains National Park and vicinity for food content analysis. Grasses and the other herbaceous leaves and stems, squawroot (*Conopholis americana*), huckleberries (*Gaylussacia* spp.), black cherry (*Prunus serotina*), acorns from oaks (*Quercus* spp.), blackberries (*Rubus* spp.), and blueberries (*Vaccinium* spp.) composed 81 percent of the diet by volume. Eleven percent of the food consumed was animal matter, principally Coleoptera and Hymenoptera. Artificial food constituted 6 percent of the diet. The most critical season with regard to food availability appears to be late fall because mast (nuts) is the only preferred natural food source available and mast failures occur frequently. There is additional evidence that nutrition, productivity, movement, and bear/person incidents are also influenced by feeding ecology of the species.

Black bears must fulfill nutritional needs for the entire year in 6-8 months. Furthermore, much of the bear's growth and weight gain takes place in late summer and fall, when it must obtain enough food for normal body maintenance, storage of body fat for the winter, and production and maintenance of cubs by females. Knowledge of the kinds of foods, their quantity, quality, and utilization are important to biologists and managers for determining management procedures.

Food habits of black bears in the Southeast are not well documented. This research was undertaken to determine the seasonal diets of black bears in the Great Smoky Mountains of Tennessee and North Carolina and to relate food habits to some possible nutritional, ecological, and management implications.

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STUDY AREA

The study area included the Great Smoky Mountains National Park (GSMNP) in Tennessee and North Carolina and 6 wildlife management areas in the southern Appalachian Mountains of North Carolina. This area is part of the Blue Ridge Province (Fenneman 1938:172), with steep slopes and narrow valley bottoms ranging from 221 m to 2,025 m.

Over 1,300 species of flowering plants have been identified in the southern Appalachians (Stupka 1964:10). These mountains comprise a complex of several vegetative cover types, conforming in a general way to varying altitudinal limits in drainage basins (Kendeigh 1942), with Fraser fir (*Abies fraseri*) and red spruce (*Picea rubens*) on the highest ridges and hickory (*Carya* spp.) and oak on the lower ridges. Trees in the lower parts of these drainages are chiefly cove hardwoods, with northern hardwoods predominating in upper portions of the valleys and on slopes. There are at least 6 distinct forest associations covering over 95 percent of the study area (Great Smoky Mountains National Park 1969:5-10): spruce-fir, cove hardwood, hemlock (*Tsuga canadensis*), northern hardwood, closed oak, and open oak. Common fruit producers are 10 species of oak, 7 species of hickory, 2 species of cherries (*Prunus* spp.), and 6 species of grape (*Vitis* spp.) (Stupka 1964:37-38, 47-51, 84-85, 105-106). The remaining part of the study area is covered by grassy balds. Many of these balds are being invaded by serviceberry (*Amelanchier* spp.), blackberry, and blueberry.

Much of the study area is in second-growth timber less than 50 years old. The variety of understory plants included 2 species of huckleberry, 15 of blackberry, and 12 of blueberry (Stupka 1964:78-81, 124-128).

Precipitation varies and is generally distributed evenly among the seasons, averaging 140 cm per year at lower elevations to 229 cm at higher elevations. Temperature ranges in the lower elevations from a mean of 4 C in January to 23 C in August (extremes, −21 C and 32 C). With each 1,000-m increase in elevation, the temperature decreases approximately 4 C. The ranges of precipitation and temperature combined with the variety of topographic exposures produce a diversity of microhabitats.

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METHODS

A total of 1,025 scats and 75 stomachs were collected between June 1969 and January 1972. Hatler (1967) appraised scat analysis as a technique to determine food habits of bears. He found that fresh green plant material appeared nearly the same in both volume and form after passing through the digestive tract of a bear as it did in the stomach. He also noted that animal matter may undergo substantial quantitative changes but that identity is seldom lost, due to the presence of some material resistant to digestion (exoskeleton, hair, claws, bones). Hatler concluded that a good collection of scats can serve justifiably as a base for nearly any food-habits study of bears.

In the GSMNP, foot trails and abandoned logging roads were selected to include various forest associations and ranges of altitude. Ten trails covering approximately 228 km were walked at 2-week intervals for collecting bear scats. Each trail was walked 14 times a year for a total of 9,600 km over the 3-year period.

Areas surrounding 10 shelter cabins and 1 garbage pit in the GSMNP were searched for scats at 2-week intervals. Scats were also collected from campgrounds and picnic areas if they appeared to be recently deposited. In the late fall, scats were more difficult to find because of the leaf cover.

All but 5 stomachs were collected from hunters during the open season (October-January) on wildlife management areas in North Carolina. Stomachs from bears in the GSMNP were obtained from 2 road kills, a poached bear, a bear killed accidentally by a drug overdose, and a nuisance bear dispatched by the NPS.

Scat and stomach samples were frozen or placed in alcohol for preservation prior to identification of food items. The frozen samples were soaked in water to make the contents pliable and we then washed through a series of sieves (mesh openings of 2mm, 1mm, and 0.25 mm), using the technique described by Tisch (1961:23-25).

Material for macroscopic examination was spread to a depth of about 6 mm. Berries, seeds, and insects often could be identified without the aid of magnification. Further examination of material with a binocular microscope continued until all food items were identified.

Volume of each item in scat or stomach contents was estimated by the methods of Clark (1957) and Tisch (1961:24). Each food item was expressed by frequency of occurrence and assigned an index value based on percentage volume of the food item: 0, trace; 1, 1-25 percent: 2, 25-50 percent; 3, 50-75 percent; and 4, 75-100 percent. From the ocular estimates, a volume index percent was calculated using the following formula:

$$\text{Volume index percent} = \frac{\text{Index value for an individual food item}}{\text{Sum of index values for all food items}} \times 100.$$

These percentages were computed for each time period (spring, summer, early fall, late fall) and the entire year. The frequency index alone can be misleading in delineating the amount of a food item actually consumed. A better evaluation of the importance of a food item can be presented if both frequency of occurrence and volume index percentage are used.

RESULTS

In the Great Smoky Mountains, black bears used the seasonally abundant foods. These foods appeared tc group naturally into 4 time periods: spring (emergence from limited winter activity through 30 June), summer (1 July through 30 August), early fall (1 September through 15 October), and late fall (16 October to approximately the first snow).

Foods of plant origin composed 81 percent by volume and foods by animal origin amounted to 11 percent by volume of the total diet of the bears (Table 1, Fig. 1). Artificial foods and debris composed the remaining 6 and 2 percent, respectively. Analysis of the samples indicated that bears consumed at least 58 different foods of plant origin, insects from 5 orders, snails (Gastropods), centipedes (Symphyla), crayfish (Crustacea), and 8 kinds of mammals. Seasonal changes in their diet are illustrated in Fig. 2.

Specific plant foods are shown in Table 1. After emergence, the bears' spring diet was 90 percent grasses and other herbaceous stems and leaves. Squawroot, a parasite that grows abundantly on the roots of trees (especially oaks), composed 10 percent of the spring diet.

During summer, intake changed to fruits and seeds (Fig. 2). Fruits of squawroot (15 percent), blackberry (12 percent), blueberry (12 percent), huckleberry (11 percent), and black cherry (10 percent) accounted for most of the diet.

The early fall diet included a variety of fruits, black cherries (23 percent) being the single most important food. The fruits of huckleberry (5 percent), blackberry (2 percent), and blueberry (3 percent) were still constituents of the diet because of the long period of-availability caused largely by altitudinal variation. At

Table 1. Food items identified in 1,025 scats and 75 stomachs of black bears in the Great Smoky Mountains by percentages of frequency and volume index, 1969-72.

Food item	Spring (145 scats, 1 stomach)		Summer (457 scats, 2 stomachs)		Early fall (326 scats, 28 stomachs)		Late fall (97 scats, 44 stomachs)		Entire year	
	Freq.	Volume index	Freq.	Volume index	Freq.	Volume index	Freq.	Volume index	Freq.	Volume index[a]
Plant origin										
Prunus serotina			7	8	29	23	13	12	18	11
Conopholis americana	13	10	15	15	1	2	T		11	9
Quercus spp.	T	T	T	T	14	14	30	30	10	9
Rubus spp.	T	T	14	12	10	2	2	T	11	8
Vaccinium spp.	1	T	13	12	4	3	T	T	10	6
Gaylussacia spp.			12	11	6	5	T	T	9	6
Gramineae	47	28	2	3	4	3	2	2	8	6
Carya spp.			T	T	6	6	9	9	3	3
Vitis spp.					4	4	10	10	3	3
Ranunculus spp.	3	1	4	3	1	T	2	T	4	2
Fagus grandifolia					6	6	6	6	3	2
Malus spp.	T		T	T	T	T	3	3	2	1
Prunus pennsylvanica			1	2	3	3			2	2
Amelanchier spp.	T	T	1	1	T	T			1	1
Amaranthus blitoides	6	2	T	T			T		1	1
Unidentified herbs	83	43	2	3	4	3	2	2	8	6
Animal origin										
Coleoptera	10	2	12	5	17	5	15	6	29	5
Hymenoptera										
Vespidae	T	T	5	3	6	5	8	8	8	3
Formicidae	3	2	3	2	2	1			8	3
Artificial food	8	4	9	8	6	6	3	2	7	6
Debris (wood, rocks, etc.)	5	1	2	2	3	1	7	2	6	2

[a] Trace quantities of 31 other plant species made up an additional 5 percent of the Volume Index.

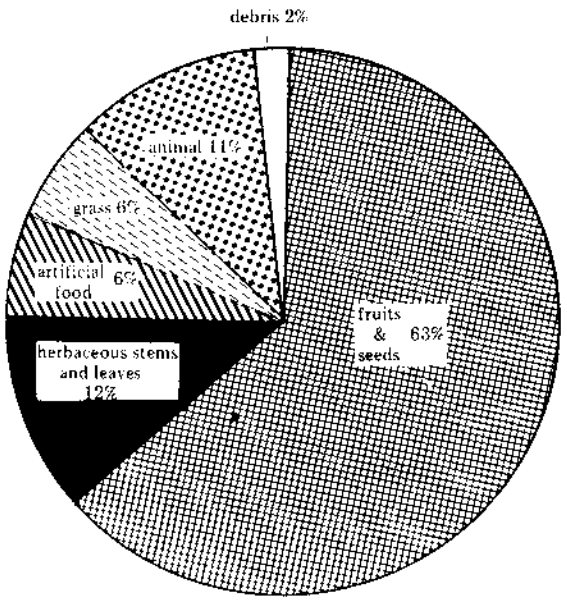

Fig. 1. Food items eaten by black bears (by percentage volume) from spring emergence to winter inactivity (entire year) in the Great Smoky Mountains National Park and vicinity, 1969-72.

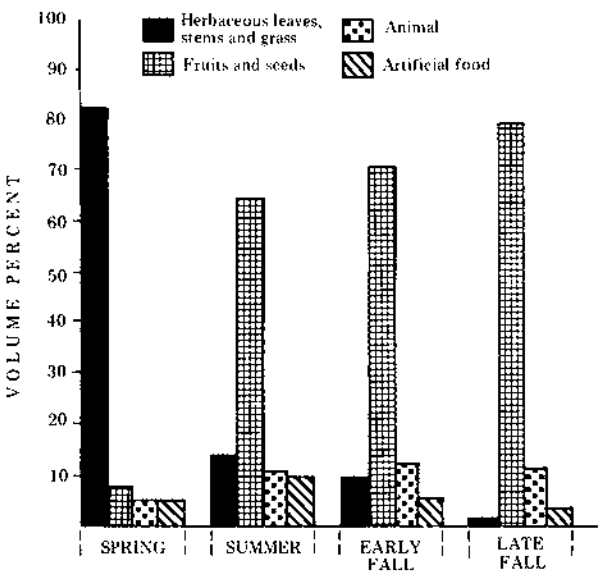

Fig. 2. Seasonal food items of black bears (by percentage volume) in the Great Smoky Mountains National Park and vicinity, 1969-72.

lower elevations, nuts were beginning to mature, with acorns (14 percent), hickory nuts (6 percent), and beechnuts (*Fagus grandifolia,* 6 percent) forming a substantial part of the diet.

In late fall, important foods were mast of oak (30 percent), hickory (9 percent), and beech (6 percent). Fruits of black cherry (12 percent) and grape (10 percent), and to a lesser degree apple (*Malus* spp., 3 percent) were also eaten.

Animal foods were in relatively low volume (11 percent) (Table 1); yellow jackets, wasps, and hornets (Vespidae, 3 percent), and ants (Formicidae, 1 percent) composed more than one-third of the animal food. When these insects were eaten, they usually composed a substantial percentage of the scat or stomach contents. Larvae and eggs were only occasionally identified with adult insects; however volume of the larvae and eggs was probably underestimated in scat samples because of their digestibility.

Beetles (29 percent) were the most frequently eaten animal food but composed only 5 percent of the diet by volume. This high frequency of occurrence and relatively low volume may be explained in 1 or more of the following ways: (1) Most species of beetle were not colonial insects and probably were eaten as isolated individuals. (2) Beetles may be a highly preferred and/or available food item. (3) Because of their large, thick cuticle, beetles were easily identified in scat and stomach remains.

The 8 kinds of mammals identified in the samples were eaten frequently. Many of the samples with mammal items also contained Diptera larvae and scavenger beetles, suggesting that the mammals consumed might have been carrion.

Consumption of artificial foods gradually increased during late spring to 4 percent, peaked in summer (8 percent), gradually decreased in early fall (6 percent), and was at its lowest level in late fall (2 percent) (Table 1). This type of food was available at campgrounds, picnic areas, backcountry shelters, roadsides, and 1 garbage dump.

DISCUSSION

Food Availability

The present food habits study suggests that black bears of the Great Smoky Mountains are largely herbivorous and exhibit distinct seasonal cycles in food consumption. During spring, bears lose weight (Beeman 1975:159). Poelker and Hartwell (1973:116) and others have referred to this period from spring emergence to the ripening of more nutritious and abundant summer foods as the "negative foraging period." Droppings observed during this period exhibit a very loose consistency. We assume that the large amounts of grasses and other herbaceous material in the diet (90 percent) contribute to this phenomenon and wonder whether the loose consistency in turn contributes to a period of conditioning of the gastrointestinal tract after a long period of quiescence. The cause-effect relationship in the above speculation is unclear.

Bears began feeding on fruit as soon as the more plentiful fruits matured. Since there are a variety of fruit-bearing plants and numerous microclimates in the Great Smoky Mountains, fruits are generally plentiful and a reliable food source from year to year. Therefore, availability of food is probably not a limiting factor for bears in summer and early fall. In fact, the plentiful foods of summer may contribute to the small home range sizes during this period (Beeman 1975).

Black cherries are available only through October; grapes and the nuts of oaks, hickories, and beech are staple foods for the remainder of the year. Baker (1950:192-193) summarized the production of nut crops of oaks, hickories, and beech as follows: oak acorns — crop failures frequent, good crops produced every 2-3 years; hickory nuts — some produced annually, good crops every 2-3 years; beechnuts — crop failures frequent, 3-5 years between good crops. Mast failures are not uncommon in the Smoky Mountains. Two have been reported in the last 6 years by the Tennessee Wildlife Resources Agency (R. H. Conley, personal communication). Bears add most of their body fat in late summer and fall (August to November); this fat is their only source of energy during winter dormancy. Therefore, scarcity of foods during August to November causes many bears to leave the confines of the park in search of food and hence they are subjected to a mortality rate higher than at other times of the year.

During fall, bears were observed climbing fruit-producing trees to feed. Adult males and females as well as cubs were noted in trees and were observed pulling in limbs with their paws and using their mouths to pick cherries, acrons, beechnuts, and hickory nuts. In addition, limbs as large as 10 cm in diameter were torn and/or chewed off and dropped to the ground. This "pruning" by bears allowed them to consume mast that otherwise would have been unavailable. Although some damage to these trees was noted, it was probably insignificant when compared with damage caused by high winds and ice storms.

The climbing and feeding behavior of bears in trees may have 2 important ramifications. Insects, particularly the larvae of the nut weevil (*Curculio* spp.), account for the greatest damage to acorns in the Southeast (Strickland 1972:22). Strickland (1972) found that over 40 percent of the white oak (*Q. alba*) and 31 percent of the northern red oak (*Q. rubra*) acorns that were well formed were damaged by insects. Korstian (1927:36) suggested that acorns subject to insect infestations during summer and early fall are also susceptible to more rapid decay than unifested ones. Climbing oak trees allows bears to obtain acorns before infestations lower the acorns' nutritional value.

Arboreal feeding by bears may also give them an advantage over most (with the exception of sciurids) other mammals dependent on mast in the fall. The wild turkey (*Meleagris gallopavo*), white-tailed deer (*Odocoileus virginianus*), gray squirrel (*Sciurus carolinensis*), and European wild hog (*Sus scrofa*) all depend on mast and likely compete with black bears, especially in years of mast scarcity.

Tisch (1961:43), Poelker and Hartwell (1973:111), and others have shown that black bears subsist mainly as vegetarians. There are 60 species of mammals in the GSMNP (Linzey and Linzey 1971:87-89), including localized high densities of white-tailed deer (Fox and Pelton 1973) and European wild hog (Great Smoky Mountains National Park 1969). During our study, wild hogs in traps were attacked by bears. Bacon (1973:91) demonstrated that meat is a highly preferred food of black bears and, since these palatable foods are present but not preyed upon, implications are that bears are opportunistic and eat only what is readily available.

Nutrition

This study estimates the relative percentages of food items included in the diet of the black bear but does not include the nutritional values of these foods in relations to their use. The nutritional requirements of an animal vary with age and season (Beck and Beck 1955); growing cubs and females bearing young require more energy than is needed for normal body maintenance.

The nutritional quality of foods in this study indicated that the diet is high in carbohydrates and low in protein. According to Wainio and Forbes (1941:631), the skin and pulp from black cherry, blackberry, blueberry, and grape are all less than 1.3 percent protein (wet basis); the protein content of seeds was excluded since they did not appear to be digested. The protein content of grasses varies among species but is generally between 5 and 15 percent (dry weight). The acorns of white oak and northern red oak are 3-4 percent protein (wet basis).

Insects, although estimated as a minor food item in quantity, may provide a critical source of protein for bears. For example, beetles contain 41 percent protein, wet basis (Beck and Beck 1955), and ants contain 55 percent, dry basis (Southwood 1973:7). Mammals also contribute another source of protein. However, the amount of protein a bear can utilize during digestion is unknown.

Artificial food consumed by bears was correlated with visitor use of the park and represents another possible source of protein for black bears. From our tagging and population studies, we estimated that in most years 90-95 percent of the bears seldom, if ever, visited an area where artificial food was available. We therefore concluded that artificial food may comprise a substantial percentage of the diet of a few bears but is not eaten by the majority of the population. Also, the NPS has been replacing most of the regular garbage cans with bearproof cans. This measure has probably reduced, although not eliminated, the amount of artificial food available to bears.

Jonkel and Cowan (1971:49) found a direct correlation between black bear productivity and huckleberry production in Montana. The reproductive capacity of bears in the Smoky Mountains seems to be affected by nutritional deficiencies probably caused by poor mast crops in the fall, although only direct evidence is available from our study. In 1973, the number of different litters observed ($N=13$) was the lowest of the 4-year study (Beeman 1975:164). This decrease in productivity appears to correlate with the poor mast year of the previous fall (1972). However, this correlation is not conclusive evidence because other causes may also be involved.

Movement

In 1968, a complete failure of the acorn crop from all oak species was recorded whereas hickories and beech produced some mast at low elevations (R. H. Conley, personal communication). Twenty-five bears (a 4-fold increase over the annual average harvest) were reported killed from Tennessee counties adjacent to the northern perimeter of the park. Bears killed in these peripheral areas were originally from the park because the open counties do not support resident bear populations. The next year (1969), when the production of mast was rated fair in oaks, poor in hickories, and excellent in beech, only 6 legal kills were reported from the same Tennessee counties. The next year of poor mast pro-

duction occured in 1972 (R. H. Conley, personal communication). There was no bear season in the Tennessee counties in 1972; however, 40 bears (a 7-fold increase over a 7-year average) were handled by the Tennessee Wildlife Resources Agency during late fall in Tennessee counties adjacent to GSMNP. A high percentage of these bears were young males in very poor condition. This occurrence indicates that bears sometimes move into areas outside their normal home ranges in search of food during years of mast scarcity and are killed both legally and illegally.

During the summers of 1968 and 1972, prior to poor mast crops, there was a total of 252 bear/person incidents in the GSMNP. Bear/person incidents included bears damaging pickup and trailer campers, ice coolers, and tents. During the years that immediately followed those years of poor mast production, a total of only 32 incidents were reported. Since male bears are involved in 87 percent of bear/person incidents in the Park (Beeman and Pelton 1976) and home ranges and movements of males are much greater than those of females (Beeman 1975), a high proportion of males are obviously involved in fall foraging activities on the periphery of and outside the park. The males are thus more vulnerable to various mortality factors; this differential vulnerability may partly explain the difference in average ages between the sexes in the relatively protected population in the park — males, 4.1 years; females, 6.4 years (Pelton 1976).

The periodic egress of bears (predominantly males) from the park during fall foraging activities as well as removal of male panhandlers in summer by the NPS may contribute to maintenance of the population at relatively high densities (Marcum 1974:59) if the hypothesized regulatory effect of adult male bears in the population is valid (Kemp 1976). However, severe and/or frequent mast scarcities are likely to have a detrimental effect on the population and to play a role in population regulation. Data presently being analyzed covering the past 5 years indicate that the population in the park is relatively stable.

These data emphasize the importance of the park as a dispersal point of bears to surrounding areas and illustrate how the availability of fall mast effects this dispersal, provides surplus animals for hunting, and may play an important role in regulating the population.

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