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FOOD HABITS OF BROWN BEARS IN PLITVICE LAKES NATIONAL PARK, YUGOSLAVIA

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Abstract: Brown bear (*Ursus arctos*) food habits were determined by analyzing 95 scats and by investigating feeding sites in and around Plitvice Lakes National Park, Yugoslavia. Only plant material was found in 76% of the samples, whereas 24% contained both plant and animal (mostly insects) material. At least 28 different plant and animal food items were identified. Plant material consumption varied with phenology. Important food types by season were: spring—graminoids, forbs, and ferns; summer—oats, insects, fruits, and forbs; autumn—tree fruits, nuts, and insects; and winter—nuts, fruits, and mammals. Spring food was of low nutritional value, whereas summer food was rich in nitrogen-free extract and crude fiber. Predenning food was high in nitrogen-free extract and ether extract.

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Food habits of European brown bears have been investigated by Couturier (1954), Berduco et al. (1982, 1983) and Dendaletche (1982) in France, and by Zunino (1976) in Italy. Little quantitative data on brown bear food habits, however, are available for Yugoslavia. Such information is a necessary requisite for bear management. The present study supplements the fragmentary information published by Marinculic and Cienjak (1984).

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STUDY AREA

Plitvice Lakes National Park encompasses 19,462 ha and is composed of 81% forests, 1% lakes and streams, and 18% meadows and small settlements. About 2,200 people live in the Park year-round and are supported by tourism and small-scale farming (cattle, sheep, oats, and plums). The Park is visited by 800,000 tourists annually, most of whom confine their hiking and sightseeing to established trails and boardwalks in the immediate vicinity of the lakes.

The forest below 800 m is dominated by beech (*Fagus sylvatica*); fir (*Abies alba*) and spruce (*Picea abies*) become progressively more abundant at higher elevations. Other common species are pine (*Pinus nigra*), hornbeam (*Ostrya carpinifolia*), juniper (*Juniperus communis*), and maple (*Acer pseudoplatanus*), along with shrubs and small trees such as hazel (*Cor-*

ylus avellana), dogwood (*Cornus mas*), buckthorn (*Rhamnus cathartica*), mountain ash (*Sorbus aria*), rose (*Rosa* spp.), pear (*Pyrus piraster*), apple (*Malus silvestris*), and cherry (*Prunus avium*).

The large mammal fauna of the Park includes the brown bear, gray wolf (*Canis lupus*), red fox (*Vulpes vulpes*), lynx (*Lynx lynx*), european wild cat (*Felis silvestris*), european badger (*Meles meles*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), and hare (*Lepus europaeus*).

More detailed information on the study area is provided by Huber and Roth (1983).

METHODS

Bear food habits were determined analyzing 95 brown bear scats collected from 1984 to 1986 and examining specific feeding sites in and around Plitvice Lakes National Park. Feeding sites were located by the close approach to radio-equipped bears or by actual sightings of unmarked bears. Systematic searches for scats were not conducted, but all scats found during routine telemetry work and while measuring daybeds were collected. Groups of scats were usually present at brown bear daybeds and all were collected. Scats were individually identified according to date, location, condition, and age and were frozen before laboratory analysis. Scat analysis followed procedures and techniques described by Tisch (1961), Landers et al. (1979), Mealey (1980), Craighead et al. (1982), Grenfell and Brody (1983), and LeCount et al. (1984).

Scats were washed through a sieve, and species of all items were identified when possible. The volume of each food item in a scat was measured by water displacement to the nearest milliliter. Because volume

composition of a scat is not indicative of the volume consumed (Hatler 1972), these data were also expressed in terms of their frequency of occurrence. "Frequency of occurrence" equals the total number of times a specific food item appeared in scats of the sample. "Frequency of occurrence percent" equals the total number of times a specific food item appeared in scats of the sample group divided by the total number of scats in the sample. Volumes of individual food items in each scat were summed to obtain a "total diet volume" of each item. The "percent of diet volume" was calculated by dividing the total diet volume of each specific food item by the total volume of all scats, not simply those in which the food item occurred.

Fresh samples of the more important vegetative bear foods were collected and chemically analyzed for percent moisture, crude protein, crude fiber, nitrogen-free extract, ether extract, ash, calcium, and phosphorus. Chemical composition was determined at the Department of Nutrition, Veterinary Faculty, Zagreb, Yugoslavia. Data were analyzed by groups of food items and by season (spring = Mar–May; summer = Jun–Aug; fall = Sep–Nov; and winter = Dec–Feb).

RESULTS AND DISCUSSION

From March 1984 through January 1986, 95 brown bear scats were collected during 70 field days (1.4 scats/field day). Scat collection was most successful in October ($N = 43$) and April ($N = 11$), and least in June ($N = 0$) and July ($N = 4$). This distribution may be explained in part by uneven search efforts, but may also reflect seasonal changes in bear physiology and behavior (Roth and Huber 1972, Roth 1980). Most of the scats were collected singly; 28 were found at 7 bear daybeds (range 2–10). Thirty-four scats were estimated to be less than 2 days old, 26 were 3–7 days old, and 35 were more than 8 days old. The average scat weight was 263.1 g (range 20–1,280 g), and the average volume was 263.2 ml (range 15–980 ml). Forty percent of the scats contained only 1 food item, 42% contained 2 food items, 12% contained 3 food items, and 6% contained 4 items.

Scat analysis appears to be a reliable method for determining plant foods eaten by bears (Hatler 1972) but is less reliable for animal foods (Grenfell and Brody 1983). Plant material was the exclusive content of 76% of the samples, 20% contained plants and insects, 2% contained plants and mammals, and 2%

contained plants, insects, and mammals. Food of plant origin composed 98% of scat volume, and food of animal origin made up only 2%.

Analysis of 95 scats showed that bears consumed at least 21 species of plants, insects from 2 families, and at least 4 species of mammals (Table 1). The consumption of vegetable and animal material by bears reflects their omnivorous feeding behavior, and the high use of vegetation indicates the importance of this component to their diet.

The general feeding cycle appeared to follow plant phenology (Fig. 1). Herbaceous plants, mostly grasses, lords and ladies (*Arum maculatum*), and ferns were the most important components of the bear diet from March to May and represent the only major foods available. Lords and ladies occurred in 67% of the spring scats, whereas young grasses and

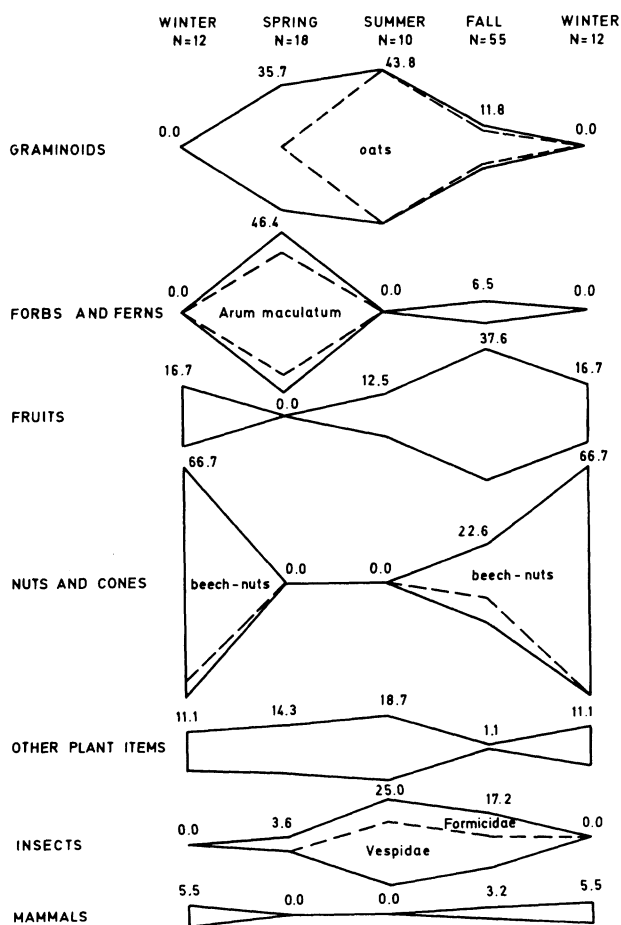


Fig. 1. Seasonal use (by relative frequency of occurrence percent) of major food types determined from 95 brown bear scats collected in the Plitvice Lakes National Park, 1984–86.

Table 1. Frequency and volume of food items found in 95 brown bear scats collected in the Plitvice Lakes National Park, 1984–86.

Food item	Frequency of occurrence	Frequency of occurrence percent	Total diet volume (ml)	Percent of diet volume
Graminoids	28	30	4307	17
Gramineae (stems, leaves, ears)	12	13	1430	6
<i>Avena sativa</i> (ears)	16	17	2877	12
Forbs and ferns	19	20	2914	12
<i>Arum maculatum</i> (leaves, stems, tubers)	12	13	1245	5
Unidentified forbs (leaves)	6	6	799	3
<i>Phyllitis scolopendrium</i> (leaves)	4	4	355	1
<i>Aposeris foetida</i> (leaves)	1	1	20	< 1
<i>Viscum album</i> (berries)	1	1	495	2
Fruits	40	42	7683	31
<i>Prunus domestica</i>	13	14	3450	14
<i>Pyrus</i> spp.	11	12	2161	9
<i>Cornus mas</i>	9	10	539	2
<i>Malus sylvestris</i>	7	7	808	3
<i>Crataegus monogyna</i>	4	4	85	< 1
<i>Rubus fruticosus</i>	3	3	401	2
<i>Prunus avium</i>	2	2	85	< 1
<i>Rosa</i> spp.	2	2	33	< 1
<i>Sorbus aria</i>	1	1	118	1
<i>Rhamnus cathartica</i>	1	1	3	< 1
Nuts and cones	33	35	9330	37
<i>Fagus silvatica</i>	27	28	8930	36
<i>Corylus avellana</i>	4	4	352	1
<i>Juniperus communis</i>	2	2	30	< 1
<i>Castanea sativa</i>	1	1	18	< 1
Other plant items	10	11	434	2
<i>Picea abies</i> (needles)	4	4	57	< 1
Bark of tree	4	4	52	< 1
Dry leaves	3	3	325	1
Insects	21	22	229	2
Vespidae (mature, larvae)	12	13	101	1
Formicidae (mature, larvae)	9	10	128	1
Mammals	4	4	108	< 1
Unidentified small mammals	3	3	65	< 1
<i>Cervus elaphus</i>	1	1	43	< 1

ferns occurred in 78%. These taxa were available every year on the study area. Plants consumed in spring were high in crude protein (2%-5%) and water (80%; Table 2). The protein content of preflowering graminoids is higher than that of postflowering plants and the highest protein digestibility is also associated with the preflowering phase (Mealey 1980). Bears were using grass-type foods when the protein content was greatest. The only plant food with high nitrogen-free extract in spring was the tuber of lords and ladies, and bears began digging for this item early in the season (Table 2).

During plant growth in spring and early summer, plant protein increases, then decreases with vegetative

maturity as nitrogen-free cell wall components are produced for structural support (Greenwood and Barnes 1978). Exceptions to this general trend are plants with seeds that are high in protein (Robbins 1983). In summer, the green plants of spring are replaced in the bear diet by cultivated oats and summer fruits (*Prunus avium*, *Rubus fruticosus*). Oat consumption peaked in August and early September. Bears consumed large amounts of oat seeds (12% of total diet volume, present in 70% of summer scats). Oat ears were high in nitrogen-free extract (57%) and crude protein (11%).

The autumn diet was composed primarily of fruits, particularly plums, pears, and apples (53% of vol-

ume), and nuts (33% of fall scat volume) (Table 3). Fruits occurred in 64% and nuts in 38% of the fall scats. Fruits were high in nitrogen-free extract (up to 35%), whereas nuts (beechnuts and hazelnuts) were high in ether extract (up to 65%), nitrogen-free extract (up to 61%), and crude protein (16%). We observed claw marks of bears that climbed hazel trees and plum trees to feed on nuts and plums before the fruits dropped. Fruits of dogwood were abundant in fall 1984 and occurred in 16% of fall scats but were scarce during fall 1985 and were not present in scats collected that year.

During the predenning period, bears depended heavily on beechnuts (Fig. 1). Irregular annual production of beechnuts may result in nutritional deficiency in bears in years when availability of these nuts is low.

Many species of delicate forbs were probably underestimated in the diet because only small quantities of residual plant skeletal material were present in the bear scats.

The results of the present investigation demonstrate the importance of vegetation in the bear diet

and illustrate cyclic feeding patterns consistent with plant phenology. The study also shows that insects were the most frequently (22% of scats) eaten animal food but comprised only 1% of diet volume. Underground nests of wasps (Vespidae) and anthills (Formicidae) were excavated by bears during summer and fall; larvae and adults were consumed. Insects may be the only consistent source of high-quality animal protein available to bears in our study area; according to Southwood (1973), ants contain more than 50% protein.

Mammalian remains are not usually detected in bear scats unless bone or hair is present. It is likely that this food source is under-represented in our study, because field observations indicate that predation on red deer and roe deer may occur, and a bear scat with red deer remains was found near a deer carcass.

Intensive digging for small mammals occurred in fall, and parts of small mammals were found in 3% of the scats. Evidence of bears preying on cattle and sheep was also documented during this study. In addition, garbage and animal remains were taken oc-

Table 2. Nutrient composition of major plant foods eaten by brown bears in the Plitvice Lakes National Park, 1984–86.^a

Food item	Moisture	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Ash	Calc.	Phos.
Graminoids								
<i>Avena sativa</i> —ears	12.88	10.85	10.86	57.06	5.23	3.13	0.36	0.17
Forbs and ferns								
<i>Arum maculatum</i>								
—leaves	83.50	4.49	0.54	9.76	0.87	0.84	0.08	0.04
—stems	90.00	0.95	0.42	7.67	0.24	0.72	0.05	0.02
—tubers	75.30	1.56	0.50	21.59	0.21	0.84	0.07	0.03
<i>Phyllitis scolopendrium</i>	79.82	3.55	2.56	11.49	0.63	1.95	0.09	0.04
<i>Aposeris foetida</i>	86.20	2.35	1.15	7.18	1.04	2.08	0.42	0.02
<i>Viscum album</i> —berries	75.24	1.38	0.66	19.44	2.43	0.86	0.11	0.05
<i>Allium ursinum</i> ^b —leaves	86.90	3.08	0.63	8.07	0.64	0.68	0.03	0.04
<i>Petroselinum sativum</i> ^b	88.80	3.71	0.72	4.85	0.43	1.49	0.16	0.07
<i>Cirsium oleraceum</i> ^b	89.50	1.61	0.83	5.77	0.45	1.84	0.36	0.03
Fruits ^c								
<i>Prunus domestica</i>	81.80	0.10	0.44	16.74	0.46	0.46	0.03	0.02
<i>Pyrus</i> spp.	74.98	0.58	3.48	18.75	1.67	0.56	0.06	0.03
<i>Cornus mas</i>	77.97	1.25	2.21	15.36	2.57	0.65	0.08	0.02
<i>Crataegus monogyna</i>	58.40	1.97	5.59	31.45	1.47	1.12	0.21	0.04
<i>Rubus fruticosus</i>	83.38	1.36	2.90	10.40	1.55	0.41	0.06	0.02
<i>Rosa</i> spp.	45.54	3.39	12.37	34.65	2.14	1.92	0.33	0.06
Nuts and cones								
<i>Fagus silvatica</i>	15.60	14.61	16.61	31.22	18.44	3.52	0.61	0.28
<i>Corylus avellana</i>	6.25	16.87	5.16	4.99	64.56	2.17	0.25	0.26
<i>Juniperus communis</i>	28.50	2.63	3.53	61.16	1.70	2.48	0.46	0.05

^a All results reported as percent of dry weight.

^b Direct evidence of use but not represented in scats.

^c Samples were whole, ripe fruits.

Table 3. Seasonal variation in frequency and volume of food categories found in 95 brown bear scats collected in the Plitvice Lakes National Park, 1984–86.*

Food category	Variable*	Winter N = 12	Spring N = 18	Summer N = 10	Fall N = 55	Total N = 95
Graminoids	FO	0	10	7	11	28
	FOP	0	56	70	20	30
	TDV	0	1,415	1,610	1,282	4,307
	PDV	0	34	88	9	17
Forbs and ferns	FO	0	13	0	6	19
	FOP	0	72	0	11	20
	TDV	0	2,425	0	489	2,914
	PDV	0	58	0	3	12
Fruits	FO	3	0	2	35	40
	FOP	25	0	20	64	42
	TDV	41	0	85	7,557	7,683
	PDV	1	0	5	53	31
Nuts and cones	FO	12	0	0	21	33
	FOP	100	0	0	38	35
	TDV	4,640	0	0	4,690	9,330
	PDV	98	0	0	33	37
Other plant items	FO	2	4	3	1	10
	FOP	17	22	30	2	11
	TDV	7	315	82	30	434
	PDV	<1	2	5	<1	2
Insects	FO	0	1	4	16	21
	FOP	0	6	40	29	22
	TDV	0	20	53	156	229
	PDV	0	1	3	1	1
Mammals	FO	1	0	0	3	4
	FOP	8	0	0	6	4
	TDV	43	0	0	65	108
	PDV	1	0	0	1	<1

* FO = frequency of occurrence; FOP = frequency of occurrence percent; TDV = total diet volume; PDV = percent of diet volume. Frequency of occurrence of food categories shown in this table is less than frequency of occurrence in Table 1 listing the species within the category. This is because in some instances 2 or more specific items occurred in a single scat but represented a single category and therefore are recorded here as a single occurrence.

casionally from several baiting spots and garbage dumps around the park boundaries.

The present study of food habits suggests that brown bears of the Plitvice Lakes National Park are largely herbivorous and exhibit distinct seasonal cycles in food consumption (Fig. 1). The most important food items in bear diets are lords and ladies and beechnuts. Lords and ladies is the common ground cover in beech forests during spring and early summer; bears feed heavily upon it after hibernation, when other green plants are not yet available. Beechnuts are produced by mature beech trees in fall and early winter and are major food items for bears during the predenning period. According to our re-

sults, mature beech forests are a major food source for bears in spring and fall. This should be considered in timber management plans to protect mature beech forests as an important part of brown bear habitat.

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