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Seasonal food habits of the European brown bear (*Ursus arctos*) in the Pindos Mountains, Western Greece

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Abstract. The seasonal diet of the brown bear *Ursus arctos* was determined by analysing the frequency of occurrence of diet items in 208 faeces in the Pindos Mountains, west of Greece, during 1994-1995. Diet varied significantly among seasons. Green vegetation was the most important food category during the spring (68.6%). Soft mast was the predominant food category in summer (105.7%), and in autumn (98.1%). Vertebrates were present in small numbers during the summer (2.8%) and higher in autumn (18.5%) and absent in spring. The proportion of plant and animal material was consistent among seasons.

Key words: seasonal diet, endangered species, omnivory

Introduction

The European brown bear (*Ursus arctos*) in Greece exists in two isolated populations. The western population occurs in Pindos mountain, covering mainly its north and central part and represents the southern limit of that distribution range of the species in Europe (Sørensen 1990). The eastern population is located in the Rodopi mountain chain. It has become a rare and threatened species throughout its range, therefore it is a priority species, listed in the Greek Red Data Book (Karandinos & Legakis 1992), and identified as an endangered species in Greece. The brown bear is a solitary species that avoids human activities and prefers undisturbed forests. The main threat is human induced mortality, as well as habitat degradation and habitat loss (Mertzani 1994). Information on the population status of the species in Greece is very limited. According to Mertzani et al. (1990), the minimum size of the total population in Greece has been estimated at 110-130 individuals. The western population consists of a minimum number of 85-110 individuals (85% of the total Greek population) and the eastern ones of 15 to 20 individuals.

The diet of brown bears in Europe has been reported by a number of authors (Zunino & Herrero 1972, Berducou et al. 1983, Cienkjak et al. 1987, Clevenger & Purroy 1991, Clevenger et al. 1992, Elgmork & Kaasa 1992, Frackowiak & Gula 1992, Clevenger et al. 1994), but quantitative information on their food in Greece is limited to a recent one on the species in the Pindos Mountains (Adamakopoulos & Adamakopoulou 1991).

The purpose of the present study was to obtain information on the diet of the brown bear in the Pindos Mountains and to ascertain its seasonal variations.

Study Area

The study area was located in the western part of Greece (39° 49' to 40° 03' N, 21° 29' to 21° 45' E), in the north-eastern part of the Pindos Mountain chain at elevations ranging from 700 to 2,249 m above sea-level with a high-relief topography. The study area was part of a bigger forest complex, which can be characterised as the core of the distribution range of the western population of the species. The climate is continental: the minimum mean monthly temperature is 0.7°C (January) and the maximum mean monthly temperature is 20.8°C (July). Snow cover lasts from October to April, and mean annual precipitation is about 908 mm.

The study area covered approximately 20,000 ha and was characterised by extensive continuous forests and grasslands in the subalpine zone as well as degraded forests due to overexploitation (Table 1). Small land ownership with non-intensive cultivation occurs at low altitudes. The forested area was primarily of the *Fagetalia* vegetation zone, and the main tree species were: black pine *Pinus nigra*, Scots pine *P. sylvestris*, Bosnian pine *P. leucodermis*, King Boris' fir *Abies borissi regis*, common beech *F. sylvatica*, silver birch *Betula pendula* and oaks *Quercus* sp. Other common plant species present include pears *Pyrus* sp., Cornelian cherry *Cornus mas*, whitebeams *Sorbus* sp., brambles *Rubus* sp., apples *Malus* sp. and plums *Prunus* sp.

Table 1. Land cover at Perivoli-Avdela-Smiksi forest complex in the Pindos Mountains of western Greece (from Tzatzanis & Theoharis 1989).

	Forest Complex		National Park		Total	
	Ha	%	Ha	%	Ha	%
Forested areas	8,610.3	49.8	1,470.2	49.2	10,080.5	49.75
Partially forested areas	3,210.1	18.6	1,093.6	36.6	4,303.7	21.24
Agricultural land	68.8	0.4	-	-	68.8	0.34
Grasslands	4,982.4	28.8	368.9	12.4	5,351.3	26.41
Rocky areas	405.0	2.3	48.8	1.6	453.8	2.24
Other (lakes, etc.)	-	-	3.9	0.1	3.9	0.02
Total	17,276.6	100.0	2,985.4	100.0	20,262.0	100.00

Human activities occur throughout the study area, except of the National Park. Logging is restricted mainly during the summer, according to the ten-year management plan under rotation system (Tzatzanis & Theoharis 1989). Apiculture and livestock grazing also take place during the summer. Hunting of wild boars (*Sus scrofa*) and other game species is permitted from September to January. Apart from brown bear population, other mammals present were wolf *Canis lupus*, wild boar, roe deer *Capreolus capreolus* and chamois *Rupicapra rupicapra*.

Material and Methods

A total of 208 faecal samples were collected from March to November in 1994 (n = 129) and in 1995 (n = 79). Fresh faeces (only) were collected in a monthly basis on predetermined routes across all the habitat types through the forest complex. In cases of two or more faeces found in the same site, they were collected and counted as one. Each faecal sample was stored separately in a container and preserved in formalin solution (5%) until analysed. Date of selection and area of collection were also recorded. Before laboratory analysis, each sample

was washed through two sieves with different mesh widths. Coarse material was retained by the larger mesh sieve and fine material by the smaller mesh sieve. The food items contained in each faeces were separated and examined under a lighted magnifying glass. Vertebrates were identified from their hair. Hair was checked microscopically and their structure categorised according to a hair key (Papageorgiou & Sfougaris 1989). The insects were identified from their elytrae (beetles), the pieces of the elytrae and the heads. Plant material was identified macroscopically using a species reference collection from the study area. Food items were subsequently classified in one of seven food categories: hard mast, soft mast, grain, green vegetation, vertebrates, invertebrates and litter.

Data were summarised in terms of the seasonal frequency of occurrence of its diet item (number of occurrences of each prey type 100 divided by the number of faecal samples). Estimations of mammals food habits by analysing their faeces could probably be biased because the mass of ingested material is not accurately reflected (Reynolds & Aebischer 1991, Weaver 1993), though this method is considered to provide a good indication of food habits (Corbet 1989, Clevenger et al. 1992, Papageorgiou et al. 1994). Brown bear food was categorised according to season: spring (April-May), summer (June-August) and autumn (September-November).

To analyse the number of occurrences, the Kolmogorov-Smirnov goodness of fit test was used to test whether each food category was distributed uniformly among the three seasons (Zar 1996). The chi-square test was used to compare differences in the proportion of animal with plant materials.

Results

A total of 306 food items was observed in the brown bear faeces from the Pindos Mountains, including 17 plant species, 4 vertebrates and 3 invertebrates. Seasonally, more samples were found in autumn (49.5%) than in spring (33.6%) or summer (16.9%) (Table 2). The plant material comprised the major food group and animal material, which includes both vertebrates and invertebrates, formed the second food group of the brown bear throughout the seasons. The most important food category was soft mast (Table 2). Green vegetation and hard mast were the second most important food categories of the diet. Vertebrates were third in importance, followed by grain, invertebrates, and litter (Table 2). Wild pear (*Pyrus pyraster*) dominated the diet in terms of frequency of occurrence, followed by grasses, cereals and legumes. Oak acorns were the most frequently consumed hard mast, and wheat (*Triticum* sp.) was the most frequent grain (Table 2). Among vertebrates, sheep were the predominant food item, followed by goats. Finally, honey bees were ranked first among invertebrates.

The proportion of plant and animal material was consistent among seasons ($\chi^2 = 2.194$, $df = 2$, $P = 0.334$), whereas food categories varied significantly among seasons. Soft mast was taken more often during summer and autumn, than spring, ($d_{\max} = 57$, $P < 0.001$) (Table 2). Wild pears, wild plums (*Prunus cocomilia*), brambles (*Rubus* sp.) and cherries (*Prunus* sp.) appeared together in over 94.3% of the summer faeces, whereas wild pears, grapes (*Vitis vinifera*), wild plums and brambles were found together in over 83.5% of the autumn faeces. Soft mast was the most important item among food categories during summer and autumn. Green vegetation was consumed more frequently in spring than in summer and in autumn ($d_{\max} = 9$, $P < 0.01$). Cereals (40%), graminoids (20%) and legumes (5.7%) were eaten in great quantities and can be characterised as the most important food items in spring (Table 2). Hard

Table 2. Seasonal frequency of occurrence (%) of food items found in the faeces of European brown bear in the Pindos Mountain, Greece, 1994-1995.

Food items	Spring (n = 35)	Summer (n = 70)	Autumn (n = 103)	Total (n = 208)	P-value ^a
PLANT					
Hard mast					
<i>Fagus</i> sp.	2.9	2.9	4.9	3.8	<0.001
<i>Quercus</i> sp.	8.6	-	18.4	10.6	
<i>Corylus colurna</i>	-	1.4	-	0.5	
<i>Juglans regia</i>	17.1	-	2.9	4.3	
Total	28.6	4.3	26.2	19.2	
Soft mast					
<i>Prunus mahaleb</i>	-	-	1.0	0.5	<0.001
<i>Prunus cocomilia</i>	-	24.3	14.6	15.4	
<i>Prunus domestica</i>	-	4.3	3.9	3.4	
<i>Prunus</i> sp.	-	20.0	-	6.7	
<i>Pyrus pyraister</i>	2.9	25.7	25.2	21.6	
<i>Pyrus communis</i>	-	4.3	3.9	3.4	
<i>Cornus mas</i>	-	1.4	2.9	1.9	
<i>Malus</i> sp.	-	1.4	2.9	1.9	
<i>Vitis vinifera</i>	-	-	29.1	14.4	
<i>Rubus</i> sp.	-	24.3	14.6	15.4	
Total	2.9	105.7	98.1	84.6	
Grain					
<i>Zea mays</i>	-	1.4	3.9	2.4	<0.05
<i>Triticum</i> sp.	-	15.7	-	5.3	
Total	0.0	17.1	3.9	7.7	
Green Vegetation					
Grasses & other ^(b)	65.7	10.0	4.9	16.8	<0.01
Unknown	2.9	2.9	2.9	2.9	
Total	68.6	12.9	7.8	19.7	
ANIMAL					
Vertebrates					
Horses	-	1.4	2.9	1.9	<0.001
Sheep	-	-	9.7	4.8	
Goats	-	-	4.9	2.4	
Tortoises	-	1.4	1.0	0.9	
Total	0.0	2.8	18.5	10.0	
Invertebrates					
Apidae	11.4	2.9	-	2.9	<0.01
Formicidae	-	2.9	-	0.9	
Coleoptera	2.9	1.4	-	0.9	
Total	14.3	7.2	0.0	4.7	
LITTER					
Total	0.0	2.9	0.0	0.9	-

(^a) P-value based on Kolmogorov-Smirnov goodness-of-fit test and indicates statistical significant of difference among seasons.

(^b) In total, included 7.7% cereals (*Triticum* sp.) and 4.8% legumes (*Medicago* sp.).

mast exhibited two peaks in frequency of occurrence, first in spring and second in autumn, and was the second major food category in brown bear's diet during those seasons, whereas it constituted a low proportion during summer ($d_{\max} = 13$, $P < 0.001$). Walnuts (*Juglans regia*) were consumed in greater amounts than acorns (*Quercus* sp.) during spring, whereas the proportion was inverse during autumn. The proportion of beechnuts (*Fagus* sp.) in the diet was low, but consistent among seasons. Vertebrates were more important during autumn than

in summer and spring ($d_{\max} = 12$, $P < 0.001$). Principally, livestock composed a substantial portion of autumn vertebrate samples, with a predominance of sheep, and goats. However, no material from wild mammals was found in faeces analysis. Horse and tortoise were found occasionally during summer and autumn, constituting a minor proportion of the bear's diet. Grain appeared more frequently during summer than autumn ($d_{\max} = 5$, $P < 0.05$). Grain were the second major food category during summer, and they were composed mainly by wheatgrains (*Triticum* sp.). Invertebrates reached a marked peak in spring, and gradually decreased during summer and autumn ($d_{\max} = 4$, $P < 0.01$). Bees dominated in spring upon other insects, although they appeared nearly equally with ants and beetles during the summer. Litter (human garbage) constituted a minor part of total faeces and were found only during summer.

Discussion

Brown bear, as described by many authors, is an omnivorous species, and the most distinctive feature in its diet is the highly frequency of occurrence of green vegetation (Mealey 1980, Berducou et al. 1983, Cienjak et al. 1987, Clevenger et al. 1992, Elgmork & Kaasa 1992). Typically, the species feeds on all kind of plants, insects and may occasionally take carrion. Brown bears in Pindos Mountains fed on what was available seasonally and the most important food category was soft mast, green vegetation and hard mast (Table 2). A similar trend has been reported for brown bears in the French Pyrenees (Berducou et al. 1983) and in the Cantabrian mountains of Spain (Clevenger et al. 1992) where the species fed on fruits, herbage, insects and herbaceous plants, masts and ungulates, respectively. In the present study, vertebrates ordered third in importance and the proportion of plant and animal material was consistent among seasons. Autumn faeces contained more various food items comparing to spring ones and this can be explained by an increasing availability of mature fruits at this time.

Early in the spring and after the long winter sleep, bears seem to require a large amount of food to meet the increased energetic demands for themselves and for their cubs. However, most likely, bears maintain a low metabolism during this period, because they cannot ingest a high-protein diet (Nelson et al. 1975, Nelson 1980). Such a mechanism also may be needed early in the spring when only a few high-quality foods are available. The low diversity of food items during spring period reflects the scarcity of foraging options. Thus, in order to obtain the basic energetic demand at this time and to avoid the food shortage and low temperatures of high altitudes, bears move to lower altitudes (700 m) and feed on the cereals and legumes cultivated around small villages. These two food items were found to be the main food in their diet in spring, probably due to the higher content of soluble nutrients and proteins and lower indigestible components such as cellulose and lignin in the new sprouted grasses (Mealey 1980, Hamer & Herrero 1987). Qualitative energetic requirements at this time are covered by the consumption of hard mast and small amount of invertebrates. The absence of wild ungulates in the bears' diet results from the low density of these species in the area as well as the arrival of nomadic herds of domestic ungulates by the beginning of the summer.

The low quality and diversity of the food consumed by bears, as reflected in their faeces, gradually changes by the beginning of the summer when cultivated and wild fruit appear. In this period, bears require a greater quantity of their food with high quality, such as fleshy fruit, which constitute the main food category in the diet. Therefore, it seems that in areas where brown bears attain at least moderate densities, fruit may be a basic factor, orientating

the distribution of brown bears, even though the availability of ungulates can likewise influence brown bear population densities (Kaal 1976, Filonov 1980, Reynolds & Garner 1987, Mattson et al. 1991). Fruit that contain a large portion of digestible carbohydrates are more efficiently converted to fat (McDonald et al. 1981, Brody & Pelton 1988), and may accelerate the process of fat accumulation during hyperphagia in fall. Brown bear diet during summer in the Pindos Mountains is supplemented by foraging on the nomadic herds of ungulates that have appeared in the area in the meantime. The continuous consumption of fleshy fruits by brown bears lasts from late July or early August to October. Before winter hibernation and their removal to the winter quarters, brown bears consume a large amount of hard mast, which is available at this time, and they increase the frequency of attacks on the last remaining domestic ungulates.

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