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Seasonal changes in food composition of the brown bear (*Ursus arctos*) from the edge of its occurrence – Eastern Carpathians (Slovakia)

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Abstract. The food composition of the brown bear diet was studied on the basis of 215 excrement samples, which were collected in 2008-2010 in the area of the Eastern Carpathians (Poloniny National Park). The seasonal changes in food composition reflected the supply of the environment, which is nowadays influenced by human activities. This situation resulted in a stronger adaptation of bear to anthropogenic food sources of plant origin compared to historical data from the Carpathians. We identified diagnostic groups and food components consumed by bears in individual seasons of the evaluated period. In spring, crops provided by hunters were found to be the diagnostic group; and corn, silage, rape, bark and wood were diagnostic components. In summer, invertebrates were the diagnostic group; and ants, cherries and grass were the diagnostic components. In autumn, fruit were the diagnostic group; and apples, pears, blackberries, plums and acorns were the diagnostic components. In winter, hard mast and crops provided by hunters were diagnostic groups; and beechnuts, sunflower, rape, wheat, corn and corn silage were diagnostic components. From the nutritional point of view, crops provided by hunters dominated in spring and summer, and hard mast dominated in autumn and winter.

Key words: excrements, ecology, anthropogenic food sources, periphery of distribution, management

Introduction

The study area, situated in the north-eastern part of Slovakia at the borders with Poland and Ukraine, is a region located at the periphery of distribution of the brown bear for a long time (Feriancová 1955, Hell & Sládek 1974, Sabadoš & Šimiak 1981, Finďo et al. 2007, Koreň et al. 2011). Although during the 20th century the information about the occurrence of the brown bear in the area of the Bukovske hills in the Eastern Carpathians of Slovakia is incomplete; Štofik et al. (2010) documented significant growth of the bear population in this region over the last decades. This population growth can be explained by the reduction of human settlements and increasing forestation (Olah et al. 2006), and by the protection of the brown bear. According to the Habitats Directive (Annex IV of 92/43/EEC Directive), the Slovak Act on Nature and Landscape Protection (No. 543/2002) and the Decree of the Ministry of Environment (No. 24/2003), the brown bear is a species of European importance with high protection priority. Similarly, in Poland the brown bear is under strict protection (Selva et al. 2011), and in Ukraine the brown bear is listed in the Red Book of Ukraine (Delehan et al. 2011). Hence, hunting of the brown bear is not allowed inside and in the immediate vicinity of the study area, due to which the population of the brown bear has been growing in all three countries (Jakubiec 2001, Štofik et al. 2010, Delehan et al. 2011).

Although the brown bear is one of the large carnivores, plant components prevail in its diet (Cicnjak et al. 1987, Ohdachi & Aoi 1987, Jamnický

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1988, Frackowiak & Gula 1992, Gula et al. 1998, Jakubiec 2001, MacHutchon & Wellwood 2003, Rigg & Gorman 2005, Sidorovich 2006). Animal ratio in brown bear diet is positively correlated with latitude (Vulla et al. 2009) and snow cover, and negatively with temperature. In the areas with higher snow cover, lower temperature and less food supply, bears consume significantly more vertebrates, and less invertebrates and hard fruits (Bojarska & Selva 2012). However, food composition of the brown bear is not constant, but changes inter- and intra-annually, as well as in long-term time frame reflecting the habitat composition (Naves et al. 2006). Bears similarly like other animal species react to the availability of food sources and primarily utilise easily accessible food. The supplementary feeding of ungulates, particularly wild boar, has become a common part of hunting management over the past 30 years in Slovakia (Hell et al. 2005). This provides readily available food sources also for bears. Huber & Kusak (1997) revealed that due to the presence of human food sources some bears may remain active most of the winter. Dietary studies can thus reveal changes in consumption, which can be very helpful for conservation and management actions.

However, only a few research works on bear diet in Europe describe the food composition of the brown bear in winter because bears are generally expected to hibernate during winter. Winter is usually included in the analysis only in the southern latitudes (e.g. Slobodyan 1976, Cicnjak et al. 1987, Naves et al. 2006) in contrast to the works from the north (Dahle et al. 1998, Persson et al. 2001, Sidorovich 2006, Vulla et al. 2009). In the Carpathians, seasonal changes in the diet based on the analysis of faeces were evaluated by Slobodyan (1976), Frackowiak & Gula (1992) and Rigg & Gorman (2005), but only Slobodyan (1976) included winter in the evaluation. Considering the presence of human food sources and the climate warming reported in the last decades, which is coupled with the reducing snow cover in winter, this season should not be omitted from the seasonal analyses aimed at examining the dietary demands and behaviour of the animals.

Hence, the aim of this work is to evaluate the seasonal changes in the bear consumption of individual food components in the assessed region including winter and reveal which components are constant over the whole year. The underlying hypothesis of the work is that due to the increasing bear population and the applied hunting management the composition of bear's diet may be influenced not only by the natural food supply of the environment, but also by anthropogenic sources. For this purpose the group of "crops for hunting" was defined. It encompasses all grain and fleshy forage that is repeatedly spread by man at selected sites within the frame of hunting management for wild boar (*Sus scrofa*). It represents so called "bait" feeding, which stimulates significant population growth of wild boar. This was documented also by two-fold increase of wild boar venison between 1969 and 2003 in Slovakia (Hell et al. 2005).

Study Area

The study area (Fig. 1) is located in the Carpathians, Eastern Carpathian province, subprovince Outer Eastern Carpathians and the Poloniny region (Mazúr & Lukniš 1986). The samples of faeces were collected in the area of the National Park (NP) Poloniny. The area of NP (48°55′-49°12′ N, 22°10′-22°34′ E) is primarily oriented to the southwest at an altitude from 250 to 1208 meters above sea level (average 608 m a.s.l.) and with slopes 7°-17° (Štofik & Saniga 2012). In 1980, almost 10000 inhabitants (245 inhabitants per 1 km^2) lived on the area of the current NP. In the 1980s, the Starina water reservoir for drinking water was built, and for that reason seven villages were removed and demolished. In 2010 (©Statistical Office of the Slovak Republic), 2447 inhabitants (60 inhabitants per square km) in ten villages were registered. These population changes caused the disappearance of the traditional land use and resulted in visible successional changes. In 2003, forest (85.5 %) was the dominant feature of the landscape structure. Meadows and pastures (8.5 %), fields (2.1 %) and other landscape elements covered only a minimal area (Olah et al. 2006). Currently, 89 % of forests are composed of deciduous tree species (© National Forest Centre 2010). The dominant tree species is common beech (*Fagus sylvatica*, 65 %). At higher altitudes, silver fir (*Abies alba*, 2 %), and non-native tree species such as Norway spruce (*Picea abies*, 4 %) and European larch (*Larix decidua*, 4 %) are admixed. At lower altitudes, stands also contain hornbeam (*Carpinus betulus*, 4 %), grey alder (*Alnus incana*, 4 %) and oak (*Quercus* spp., 3 %).

The mean daily temperature below 0 °C occurs during 78 days per year in the southern parts, 96 days in the northern parts, and over 118 days in the ridge locations on average. The average maximum depth of snow cover is from 30 to 40 cm at lower altitudes, and around 70 cm in the mountains. In the lowlands and the southern parts, snow cover occurs on 70 days per year on average, but 80 days in the valleys and

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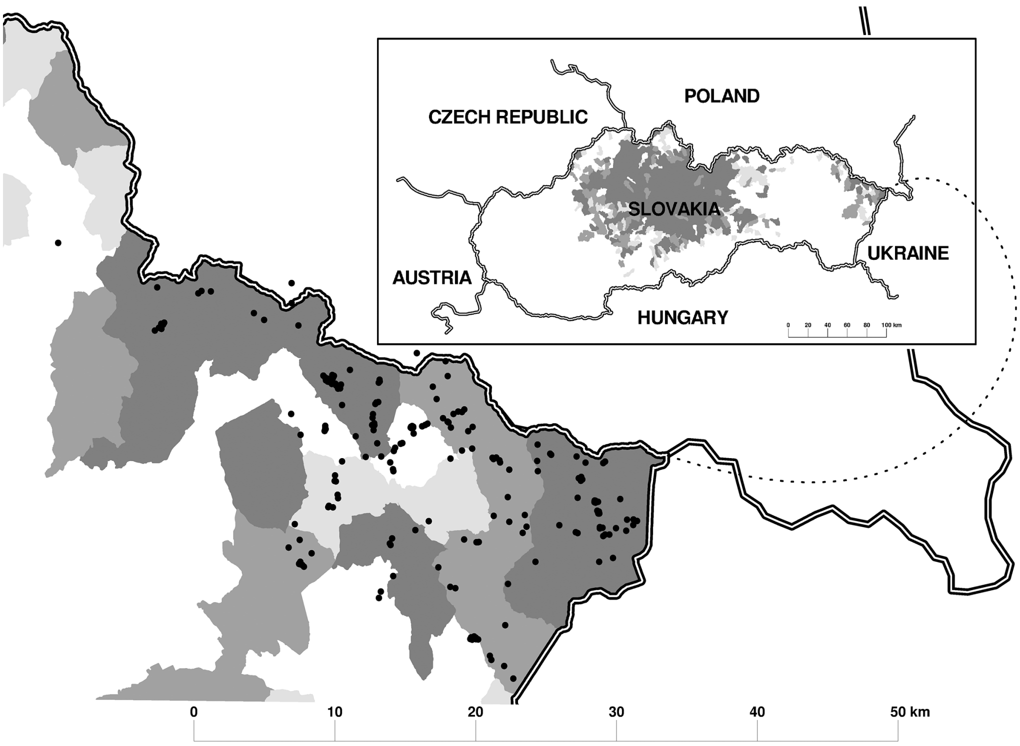

Fig. 1. Dispersion of analysed sample excrements (n = 215) shown with black points. The map shows the distribution range of bears (2008-2010) according to the reports of hunting associations during 1 , 2 or 3 assessed years (© National Forest Centre 2011).

on the north, and over 120 days in the ridge locations (Šťastný 1988).

In the study area, bear population has been increasing from the long-term perspective (Štofik et al. 2010). On the base of non-invasive samples of excrements and fur taken in 2008 and 2009 that were used for DNA analysis of the population in the assessed region, the population consists of at least 15 individuals (Straka et al. 2012). The highest estimate obtained by the method of Kohn et al. (1999) was 69 individuals (SD 304). The method of Eggert et al. (2003) estimated 28 individuals (SD 41.7) and the method by Chessel (in Valière 2003) implemented in GIMLET program (Valière 2002) estimated that the population comprised 19 individuals (SD 3.57) (Straka et al. 2009).

Material and Methods

The faeces were sampled during 2008-2010. In winter, snow-tracking of individual animals was performed (Pazhetnov 1990, Jakubiec 2001) in parallel with collecting the excrements. In the periods without snow cover, the faeces were collected systematically during the whole period following the method of Persson et al. (2001) from the areas with reported and suspected occurrence of bear (orchards, roads, feeding racks). GPS device (Garmin eTrex Vista H) was used to store the position and altitude of localities. From the suitable excrements, samples were taken for the genetic analyses (Straka et al. 2012).

Individual food components in faeces were identified macroscopically by visual analysis (Clevenger et al. 1992). Hairs of mammals were identified in the faeces from the cuticle surface and were compared with the reference material.

The diet composition was evaluated using several different quantification methods to obtain a more general overview and understanding and to enable the comparison with other works. Frequency analysis is the basic analysis that evaluates the presence or absence of individual food components and their frequency (%F) in the bear diet. For each component its relative proportion was estimated as a ratio between the number of samples containing the particular component and the total number of the analysed samples from the given season. Hence, the summary value %F can exceed 100 %, because one excrement sample usually contains several components (Rigg & Gorman 2005).

Second, we performed volumetric analysis of food components. The volumetric proportion of each food component in all samples was quantified in two ways. The first approach (%VO) was based on the visual estimation of the proportion of the food component in the excrement volume (Frackowiak 1997, Rigg &

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Gorman 2005). The results of this calculation were used for the comparison with previous works from the surrounding area (Slobodyan 1976, Frackowiak 1997, Rigg & Gorman 2005).

The second variant (%V) of estimating volumetric proportions of food components accounted for the size of excrements. Hence, during excrement gathering, the excrements were visually categorised into three size categories: large, medium and small (Ohdachi & Aoi 1987). In each size category, the excrement size was measured experimentally on a sub-set of samples. The obtained mean volumes for each size category (227.54 cm^3, 681.11 cm^3, and 1133.33 cm^3) were multiplied with the estimated proportion of the individual food components in the excrements. Thus, we obtained the volumes of food components in the excrements. The volumes of every food component were summed up over one season and divided by the sum of volumes of the collected excrements in the analysed season. This volumetric proportion represented the basis for the subsequent calculations of the amount of consumed dry mass (%D) and energy (%E).

The volumetric percentages of individual components in excrements do not need to reflect the amount of the consumed dry mass (%D). Hence, to derive the proportions of the components consumed we used so called „correction factors" CF_1 derived from the feeding experiments with captive bears (Hewitt & Robbins 1996). The following values of CF_1 coefficients were used: 0.26 for grasses, herbs, silage, mushrooms, leaves, needles, bark and wood; 0.51 for apples (*Malus* spp.) and pears (*Pyrus communis*); 0.87 for blackberries (*Rubus fruticosus*), 0.93 for plums (*Prunus domestica*), sloes (*Prunus spinosa*), and rose hips (*Rosa canina*); 1.1 for invertebrates; 1.5 for hard mast and crops; and 2.0 for large mammals. The components that are insignificant or their impact is unknown (soil, unidentified) were excluded from the analysis of dry consumed material.

The amount of consumed energy (%E) per component and period was estimated from volumetric values using the second group of "correction factors" (CF_2): 17.7 kJ/g for bees (*Apis mellifera*), wasps (Vespidae), ants (Formicoidea), larvae (as for ants, wasps and bumble-bees: Swenson et al. 1999, Pearson et al. 2001); 24.1 kJ/g for beechnuts (*Fagus sylvatica*); 21.3 kJ/g for acorns (*Quercus* spp., USDA 2007); 12.6 kJ/g for wheat (*Triticum* spp.); 13.7 kJ/g for corn (*Zea mays*); 22.7 kJ/g for sunflower (*Helianthus annuus*) and oil-seed rape (*Brassica napus*); 2.1 kJ/g for plums, sloes, and rose hips; 1.8 kJ/g for apples; 1.7 kJ/g for pears; 2.4 kJ/g for cherries (*Cerasus* spp.); 1.6 kJ/g for blackberries; 1.0 kJ/g for mushrooms (bolete *Leccinum albostipitatum*); 4.4 kJ/g for roe deer (*Capreolus capreolus*); 4.8 kJ/g for wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), and other vertebrates (VUP 1996-2002); 1.2 kJ/g for grass and herbs; 4.0 kJ/g for wood biomass (Feuereisel & Ernst 2009); and 6.0 kJ/g for corn silage (Barrière et al. 2001).

Seasonal changes in diet composition were compared with other works from the Carpathians (Frackowiak 1997, Rigg & Gorman 2005) for four seasons: spring (March-May), summer (June-August), autumn (September-November), and winter (December-February).

Diagnostic components were assessed by fidelity, i.e. the measure of the concentration of the given component in the analysed period on the base of frequency values (%F). As a statistical measure of fidelity we used *Phi* coefficient (Chytrý & Tichý 2003) and *F-test* of statistical significance of common species/components ($p \leq 0.05$), which is included in JUICE 6.5 program (Tichý 1999-2007). Apart from diagnostic components we also estimated constant components defined by the occurrence frequency (%F) greater than 30 %.

The differences in diet composition between the individual seasons and between our study and the works from the surrounding regions (Slobodyan 1976, Frackowiak 1997, Rigg & Gorman 2005) were statistically tested using the statistical test of interval estimates at 95 % significance level. The test examines the overlapping of confidence intervals, i.e. the result is significant only if the intervals do not overlap. Confidence intervals were calculated in two different ways: (1) using Boostrap method (Efron 1979) by repeating the sample 10000 times, and (2) on the base of the theory of binomial proportion (Snedecor & Cochran 1980).

Results

The analysis of 215 brown bear excrements collected in the Eastern Carpathian region (Fig. 1) during 2008-2010 detected 27 food components (Table 1), which were classified into seven main groups (hard mast, fruit, crops for hunting, herbs and woody plants, invertebrates, vertebrates and others – soil and unidentifiable components). From the observed components, corn, rape, wheat, sunflower, and silage were identified as crops for hunting (Table 1).

In the spring, crops for hunting were dominant regardless of the calculated parameter; with corn being the major component. The proportion of this

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Table 1. Seasonal changes in diet composition of brown bear (2008-2012) in the Eastern Carpathians (n = 215). %Fi = modified fidelity index – *Phi* coefficient evaluated in JUICE 6.5 (Tichý 1999-2007), %D = relative amount of consumed dry material, %E = relative consumed energy, %F = frequency of occurrence.

Season	spring (n = 35)							summer (n = 25)							autumn (n = 97)							winter (n = 58)						
Component/group	%Fi	%D	95CI	%E	95CI	%F	95CI	%Fi	%D	95CI	%E	95CI	%F	95CI	%Fi	%D	95CI	%E	95CI	%F	95CI	%Fi	%D	95CI	%E	95CI	%F	95CI
acorns															27	29	20-38	63	54-73	20	12-28		22	11-33	27	15-38	10	2-18
beechnuts		15	2-27	24	9-39	17	4-30									6	1-11	16	9-23	6	1-11	24	23	12-34	32	20-44	26	14-37
Total hard mast		15	2-27	24	9-39	17	4-30									35	25-45	79	71-87	26	17-35	24	45	32-58	59	46-72	36	24-49
apples									23	6-40	7	0-22	20	4-36	35	22	13-30	4	0-8	39	29-49		3	0-10	0	0-3	7	0-14
plums									5	0-19	2	0-12	8	0-22	10	6	1-11	1	0-5	7	2-12							
sloes		4	0-13	1	0-5	3	0-11									2	0-5	0	0-3	4	0-8		2	0-8	0	0-3	3	0-10
cherries								40	26	8-44	11	0-26	24	6-42		2	0-5	0	0-3	3	0-7							
blackberries															18	3	0-7	0	0-3	4	0-8							
pears									1	0-10	0	0-5	4	0-16	36	14	7-21	2	0-6	22	13-30							
wild rose																							0	0-2	0		3	0-10
Total fruit		4	0-13	1	0-5	3	0-11		56	35-76	21	4-38	56	36-76	42	48	38-58	9	3-15	71	62-80		6	0-12	1	0-4	14	5-23
corn	32	45	28-62	42	25-59	40	23-57		11	0-26	27	8-45	8	0-22		2	0-6	4	0-7	1	0-4	11	19	8-29	15	5-24	26	14-37
rape	19	9	0-19	14	2-26	17	4-30															16	12	3-20	15	6-25	16	6-25
wheat		5	0-15	5	0-14	11	1-22		5	0-18	11	0-26	8	0-22		2	0-5	2	0-6	1	0-4	13	10	2-18	7	1-14	16	6-25
sunflower																						20	1	0-5	1	0-5	5	0-12
silage	24	2	0-10	1	0-7	29	13-44		3	0-14	3	0-14	8	0-22		0		0		1	0-4	8	2	0-8	1	0-5	19	9-29
Total crops for hunting	33	62	45-78	62	45-78	57	40-74		19	3-35	41	20-61	16	1-31		4	0-8	6	1-11	2	0-6	22	44	31-57	39	26-52	48	35-61
grass		3	0-11	0	0-3	11	1-22	17	5	0-18	1	0-8	16	1-31		1	0-5	0	0-2	5	1-10							
mushrooms									0	0-6	0	0-3	4	0-16														
leaves and needles		0	0-4	0	0-2	9	0-19		1	0-6	0	0-5	16	1-31		1	0-4	0	0-3	26	17-35		1	0-5	0	0-2	24	13-35
wood and bark	21	1	0-5	0	0-3	9	0-19									0		0		2	0-6							
Total herbs and woody plants		4	0-13	0	0-5	23	8-37		6	0-19	1	0-10	36	16-56		3	0-6	1	0-3	33	24-42		1	0-5	0	0-2	24	13-35
bees									3	0-14	10	0-25	4	0-16														
ants		7	0-17	8	0-19	9	0-19	29	6	0-19	18	2-33	20	4-36														
larvae		2	0-10	3	0-11	3	0-11									0		0	0-1	1	0-4							
Total invertebrates		9	0-19	11	0-21	11	1-22	30	9	0-23	28	9-46	24	6-42		0		0	0-1	1	0-4							
wild boar		8	0-18	3	0-11	3	0-11																1	0-6	0	0-3	5	0-12
roe deer																0	0-2	0	0-1	1	0-4							
red deer																7	2-12	3	0-7	5	1-10		3	0-9	1	0-5	2	0-7
other vertebrates		1	0-5	0	0-3	3	0-11		11	0-26	9	0-24	4	0-16		3	0-7	2	0-5	5	1-10							
Total vertebrates		8	0-19	3	0-11	6	0-16		11	0-26	9	0-24	4	0-16		10	4-16	5	1-10	11	5-18		4	0-10	1	0-5	7	0-14
soil						3	0-11	21					12	0-27						3	0-7							
unidentifiable						3	0-11						8	0-22						9	3-15						10	2-18
Total other items						6	0-16						20	4-36						9	3-15						10	2-18

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Table 2. Comparison of seasonal changes of the proportion of food components with the works from the vicinity.

Author	Position with regard to the assessed area – country	Food components		spring		summer		autumn		winter	
				%VO	95%CI	%VO	95%CI	%VO	95%CI	%VO	95%CI
Slobodyan (1976)	200 km east – Ukraine	n		62		69		51		41	
		Plant food		58	46-71	71	60-82	63	49-77	51	35-67
		Vertebrates		42	30-55	29	18-40	37	23-51	49	33-65
		Anthropogenic food	Farm animal	2	0-6			8	0-15	10	0-19
			Crops								
			Refuse								
Frackowiak (1997)	North (adjacent) – Poland	n		81		19		84			
		Plant food		61	51-72	66	43-88	83	74-91		
		Vertebrates		36	26-47	31	9-54	15	7-23		
		Anthropogenic food	Farm animal	13	6-20			6	1-11		
			Crops	17	9-26			8	2-13		
			Refuse								
Rigg & Gorman (2005)	200 km west – Slovakia	n		85		147		141			
		Plant food		84	76-92	88	83-94	92	87-97		
		Vertebrates		9	3-16	10	5-15	7	3-12		
		Anthropogenic food	Farm animal								
			Crops	13	6-20	4	1-7	25	18-32		
			Refuse	7	1-12	1	0-4	1	0-3		
This work	Slovakia	n		35		25		97		58	
		Plant food		86	74-98	78	61-95	88	81-94	90	82-98
		Vertebrates		10	0-20	9	0-24	6	1-11	3	0-9
		Anthropogenic food	Farm animal								
			Crops	52	35-69	16	1-31	2	0-6	43	30-56
			Refuse								

group was significantly higher than the proportion of the other groups (i.e. confidence interval of this group did not overlap with confidence intervals of other groups and fluctuated from 40 % to 45 % depending on the calculated parameter. The group with the second highest proportion varied depending on the parameter. In case of %F, herbs and woody plants with the proportion 23 % were ranked the second. In case of %D and %E, it was the group of hard mast with the proportion of 15 % or 24 %, respectively. The diagnostic group was the group of crops for hunting with fidelity 33 % and the diagnostic components were corn (32 %), silage (24 %) and bark and wood (21 %). Crops for hunting were also found to be the constant group (%F > 30 %) and corn was the constant component.

In the summer, the major food group was fruit (both %F and %D were equal to 56 %) containing *Malus* spp., *Cerasus avium*, *Pyrus* spp. and *Prunus domestica*. However, from the point of consumed energy (%E), fruit was ranked the third after crops for hunting (41 %) and invertebrates (28 %). In terms of frequency (%F), high proportion was also found for the groups of herbs and woody plants (36 %) and invertebrates (24 %). In case of %D, fruit group was followed by crops for hunting and vertebrates. The diagnostic groups were invertebrates with fidelity of 30 % and the diagnostic components were cherries (40 %) and ants (29 %). Fruit with %F = 56 % was a constant group in the summer.

In the autumn, fruit was again the dominant group (%F = 71 %, %D = 48 %). In case of %F, the proportion of this group significantly differed from the proportion of other groups. The second most frequent group were herbs and woody plants (%F = 33 %), within which the components leaves and needles dominated. If %D was taken as a basis for comparison, hard mast was the second most important group (35 %). According to %E, hard mast was the dominant group and acorns (*Quercus petraea*) were the dominant component with highly significant proportions equal to 79 % and 63 %, respectively. Fruit with fidelity of 42 % was the diagnostic group in autumn, and pears (36 %), apples (35 %) and acorns (27 %) were the diagnostic components. Fruit with %F = 71 % was also found to be the constant group and apples (39 %) the constant component.

In the winter, the excrements contained significant proportion of crops for hunting (%F = 48 %, %D = 44 %). However, the percentage of this component

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was not significantly different from the proportion of hard mast, which was found to be the second most frequent group. From the point of %E, hard mast was the dominant component with 59 % proportion. The diagnostic groups were hard mast with fidelity 24 %, and crops for hunting (22 %), and the diagnostic components were beechnuts (24 %). Crops for hunting and hard mast were also found to be constant groups in winter.

When evaluating the seasonality in the occurrence of diet components, it is possible to distinguish the components with considerable seasonal fluctuations in their proportions and the components with almost constant proportions over the year. The proportion of crops for hunting, fruit and hard mast in brown bear diet significantly varied among the seasons. The proportion of crops for hunting was the highest in the spring. In the summer, its proportion slightly decreased until it reached its minimum in the autumn. In the winter, the proportion of crops for hunting increased again (Table 1).

The maximum proportion of fruits was in the summer or autumn, followed by distinctive decrease in winter and spring. The proportion of hard mast in the brown bear diet was the highest in the winter (%E), after which it continually decreased until almost reaching 0 value in the summer and in the autumn it significantly increased again.

The components with constant proportion over the whole year, i.e. without significant differences among the seasons were: grasses, mushrooms, vertebrates and other components (soil and unidentifiable components).

In general we can state that the most significant groups of food sources identified from the faeces were crops for hunting, fruit and hard mast, since their proportions for several calculated parameters were significantly higher than of the other groups (Table 1).

Comparison of the changes at a regional scale

The analysis of the data from the area of Slovakia (95 % CI) revealed that significant differences were found only in the proportion of anthropogenic food components (Table 2). In the spring, Rigg & Gorman (2005) detected significantly lower proportion of crops than was found in our work. In contrast, in the autumn the authors observed significantly higher proportion of crops than in our research. In addition, they also found the refuse in the bear diet, which was not detected in our work. In the winter we found significant proportions of crops, but these values could not be compared with the area of the Western Carpathians as winter was not evaluated in the study of Rigg & Gorman (2005).

The comparison of our results with the findings outside Slovakia based on 95 % confidence interval revealed several differences. While Slobodyan (1976) and Frackowiak (1997) observed farm animals in bear diet, this food component was not detected in the faeces from Slovakia (Rigg & Gorman 2005 and this work). In spring and autumn, both Slobodyan (1976) and Frackowiak (1997) observed significantly lower proportion of plant food, and higher proportion of animal food than was detected in our work. Although both authors observed the presence of anthropogenic food in bear diet, Slobodyan (1976) did not detect crops among food components. Frackowiak (1997) reported significantly lower proportion of crops in spring and summer, and higher, although insignificant, proportion in autumn than was found in this work. Slobodyan (1976) also analysed winter diet of bears. When compared with our study, he revealed significantly lower proportion of plant food and significantly higher proportion of animal food in winter.

Discussion

Bears obtain their energy by the uptake of carbon compounds from food. Diet composition depends on food supply and geographic position (Bojarska & Selva 2012). In the vicinity of the assessed area, diet composition has been influenced by a man providing a wide range of food sources (Slobodyan 1976, Frackowiak 1997, Hell & Slamečka 1999, Rigg & Gorman 2005). Human activity in the vicinity of the lair frequently caused its earlier abandonment (Swenson et al. 1997, Štofik & Saniga 2012). In the southern parts of Europe, diet composition in winter was also evaluated (Slobodyan 1976, Cicnjak et al. 1987, Naves et al. 2006) whereas from the parts situated further north (Dahle et al. 1998, Persson et al. 2001, Sidorovich 2006, Vulla et al. 2009) the values representing winter are missing. However, neither Paralikidis et al. (2010) from Greece evaluated winter diet, most probably because their data represented cooler regions at altitudes from 500 to 2000 m a.s.l. In the Carpathians, only Slobodyan (1976) analysed winter diet and found significantly higher proportion of animal food components than our work (Table 2). Meat component was also found to be the significant component in winter bear diet in neighbouring Poland (Gula et al. 1998, Jakubiec 2001). In contrast, our analysis revealed much lower amount of dry consumed animal material and its energy (Tables 1,

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2). This can be explained by the availability of other plant food sources in the assessed area. The absence of farm animals in the excrements from Slovakia (Rigg & Gorman 2005 and our analysis) can be explained by strict veterinary standards restricting the usage of meat baits (Hell & Slamečka 1999) that were frequently applied in the past (Komárek 1955, Sabadoš & Šimiak 1981, Hell & Slamečka 1999). We presume that if the supply of easily accessible plant food components was reduced in the assessed region, the proportion of animal food in bear diet may increase.

Hard mast was the most significant natural component in bear diet with energy dominance in autumn and at the beginning of winter. High frequency of hard mast was also observed in Yugoslavia (Cicnjak et al. 1987, %F = 67 %) and in Spain: 50 % (Clevenger et al. 1992) and 67 % (Naves et al. 2006). Although hard mast is a group characterised with high intra-annual differences due to the occurrence of crop years, it was found to be a significant diet component in spite of pooling data across three subsequent years (2008-2010) that gave us a more general view on the bear diet in individual seasons over a longer time period.

In spring months, the majority of works (Cicnjak et al. 1987, Rigg & Gorman 2005, Naves et al. 2006, Paralikidis et al. 2010) reported the dominance of grasses and herbs. The presented work revealed a much lower proportion of grass. This may result from the abundant supply of more nutritious crops for hunting from feeding racks, which were also found to be a diagnostic group of the season. In the neighbouring region of Bieszczady, Jakubiec (2001) reported the sap of conifers in bear diet obtained by nipping off. According to Nolte et al. (2003), after leaving the lairs, bears need to refill their energetic and mineral losses, due to which they may massively damage trees and hence, also assets (Ziegltrum & Nolte 1995). This was also proved in Poland (Zyśk-Gorczyńska & Jakubiec 2010). In our work, bark and wood were found to be diagnostic components in spring, which supports the findings by Jakubiec (2001) that tree bark and sap is used by bears.

In summer, Rigg & Gorman (2005) observed a much higher frequency of grasses (%F = 52 %) and of herbs and woody plants (%F = 67 %) than was revealed in this work. Similarly, Cicnjak et al. (1987) also found grasses more frequently (%F = 44 %). Our results showed high occurrence of fruit in faeces in this season. This is because a number of fruit trees remained in the assessed area after the settlements had been displaced due to the construction of Starina water dam. In addition, the result can also be explained by the accelerated regeneration of cherry trees at stand edges resulting from the successional afforestation of the area (Olah et al. 2006). Fruit were also found to be significant components in Greece (Paralikidis et al. 2010), Spain (Naves et al. 2006), and in neighbouring Poland (Frackowiak 1997).

In autumn, fruit was dominant again, and was also a diagnostic group of the season. Similarly, in Poland (Frackowiak 1997) and Scandinavia (Dahle et al. 1998) fruit dominated in all assessed statistical indicators. However, from the point of nutrition, hard mast (acorns) dominated. The same findings were also presented by Paralikidis et al. (2010). However, in the area of the Western Carpathians, crops were the most frequently consumed material (Rigg & Gorman 2005). In Estonia, cereals were detected to be significant components in bear diet (Vulla et al. 2009), but in our study their proportion excluding corn was minimal.

Long-term study (1974-2004) revealed changes in diet composition and suggested to process these data in relation to current and future management of bear population (Naves et al. 2006). In the last years, the population of the other large omnivore in Europe – wild boar (Geisser & Reyer 2004, 2005, Bieber & Ruf 2005, Tsachalidis & Hadjisterkotis 2008, Keuling et al. 2010) has been increasing due to supplementary feeding (Geisser & Reyer 2004, Bieber & Ruf 2005). Since bears utilise food sources provided by a man for wild boar, we presume that the population growth of brown bear (Štofik et al. 2010) can also be stimulated by the supplementary feeding. Due to the fact that brown bear is a protected species, only passive (also called non-invasive) management of brown bear population is possible in the assessed area. Hence, the population growth can be stopped or slowed down by avoiding supplementary feeding and thus, reducing this influence of hunting management (Bieber & Ruf 2005).

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Literature

Barrière Y., Vérité R., Brunschwig P., Surault F. & Emile J.C. 2001: Feeding value of corn silage estimated with sheep and dairy cows is not altered by genetic incorporation of Bt176 resistance to *Ostrinia nubilalis*. *J. Dairy Sci. 84: 1863–1871.*

Bieber C. & Ruf T. 2005: Population dynamics in wild boar *Sus scrofa*: ecology, elasticity of growth rate and implications for the management of pulsed resource consumers. *J. Appl. Ecol. 42: 1203–1213.*

Bojarska K. & Selva N. 2012: Spatial patterns in brown bear *Ursus arctos* diet: the role of geographical and environmental factors. *Mammal Rev. 42: 120–143.*

Chytrý M. & Tichý L. 2003: Diagnostic, constant and dominant species of vegetation classes and alliances of the Czech Republic: a statistical revision. *Masaryk University, Brno.*

Cicnjak L., Huber D., Roth H.U., Ruff R.L. & Vinovrski Z. 1987: Food habits of brown bears in Plitvice Lakes National Park, Yugoslavia. In: Zager P. (ed.), A selection of papers from the 7th International Conference on Bear Research and Management, Williamsburg, Virginia, USA, and Plitvice Lakes, Yugoslavia, February and March 1986. *International Association for Bear Research and Management: 221–226.*

Clevenger A.P., Purroy F.J. & Pelton M.R. 1992: Brown bear (*Ursus arctos* L.) habitat use in the Cantabrian Mountains, Spain. *Mammalia 56: 203–214.*

Dahle B., Sørensen O.J., Wedul E.H., Swenson J.E. & Sandegren F. 1998: The diet of brown bears *Ursus arctos* in central Scandinavia: effect of access to free-ranging domestic sheep *Ovis aries. Wildlife Biol. 4: 147–158.*

Delehan I.V., Lushchak M.M. & Delehan I.I. 2011: Population dynamics of brown bear populations in the Carpathians Ukrainian. *Naukovij visnik NLTU Ukrainy Vip. 21.8: 16–24. (in Ukrainian with English summary)*

Efron B. 1979: Bootstrap methods: another look at the jackknife. *Ann. Stat. 7: 1–26.*

Eggert L., Eggert J. & Woodruff D. 2003: Estimating population sizes for elusive animals: the forest elephants of Kakum National Park, Ghana. *Mol. Ecol. 12: 1389–1402.*

Feriancová Z. 1955: Distribution of the some rare mammals in Slovakia. *Práce II sekcie SAV, séria biologická 1 (3): 17–19. (in Slovak with Russian and German summaries)*

Feuereisel J. & Ernst M. 2009: Verification of the food supply to game under conditions of the floodplain forest ecosystem. *J. Forest Sci. 55: 81–88.*

Finďo S., Skuban M. & Koreň M. 2007: Brown bear corridors in Slovakia. *Carpathian Wildlife Society, Zvolen.*

Frackowiak W. & Gula R. 1992: The autumn and spring diet of brown bear *Ursus arctos* in the Bieszczady Mountains of Poland. *Acta Theriol. 37: 339–344.*

Frackowiak W. 1997: Diet and food habits of the brown bear (*Ursus arctos* L.) in Polish Eastern Carpathians. *J. Wildlife Res. 2: 154–160.*

Geisser H. & Reyer H.U. 2004: Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars. *J. Wildlife Manage. 68: 939–946.*

Geisser H. & Reyer H.U. 2005: The influence of food and temperature on population density of wild boar *Sus scrofa* in the Thurgau (Switzerland). *J. Zool. Lond. 267: 89–96.*

Gula R., Frackowiak W. & Perzanowski K. 1998: Current status and conservation needs of brown bears in the Polish Carpathians. *Ursus 10: 81–86.*

Hell P. & Slamečka J. 1999: Brown bear in the Slovak Carphatians and in the World. *Parpress, Bratislava. (in Slovak)*

Hell P. & Sládek J. 1974: Trophy predators of the Slovakia. *Príroda, Bratislava. (in Slovak)*

Hell P., Slamečka J. & Gašparík J. 2005. Evaluation of meat production from wild animals in period 1969-2004. *Výskum a ochrana cicavcov na Slovensku 7: 169–177. (in Slovak with English abstract)*

Hewitt D.G. & Robbins C.T. 1996: Estimating grizzly bear food habits from fecal analysis. *Wildl. Soc. Bull. 24: 547−550.*

Huber D. & Kusak Y.J. 1997: Winter movements of brown bears in Croatia. *11th International Conference on Bear Research and Management, Graz, Austria, 1-4 September 1997: 24.*

Jakubiec Z. 2001: The brown bear *Ursus arctos* L. in the Polish part of the Carpathians. *Polska Akademia Nauk, Institut Ochrony Przyrody PAN, Krakow. (in Polish with English summary)*

Jamnický J. 1988: The food of the brown bear (*Ursus arctos* L.) in the Tatra region. *Folia Venatoria 18: 197–211. (in Slovak with English summary)*

Keuling O., Lauterbach K., Stier N. & Mechthild R. 2010: Hunter feedback of individually marked wild boar *Sus scrofa* L.: dispersal and efficiency of hunting in northeastern Germany. *Eur. J. Wildlife Res. 56: 159–167.*

Kohn M., York E., Kamradt D., Haught G., Sauvajot R. & Wayne R. 1999: Estimating population size by genotyping faeces. *Proc. R. Soc. Lond. B 266: 657–663.*

Komárek J. 1955: Hunts in the Carpathians. *Orbis, Praha. (in Czech)*

Koreň M., Finďo S., Skuban M. & Kajba M. 2011: Habitat suitability modelling from non-point data: the case study of brown bear habitat in Slovakia. *Ecol. Inform. 6: 296–302.*

MacHutchon A.G. & Wellwood D.W. 2003: Grizzly bear food habits in the northern Yukon, Canada. *Ursus 14: 225–235.*

Mazúr E. & Lukniš M. 1986: Geomorphological classification of the SSR and ČSSR, part Slovakia. *Slovenská kartografia, Bratislava. (in Slovak and English)*

Naves J., Fernández-Gil A., Rodríguez C. & Delibes M. 2006: Brown bear food habits at the border of its range: a long-term study. *J. Mammal. 87: 899–908.*

Nolte D.L., Wagner K.K. & Trent A. 2003: Timber damage by black bears. *USDA National Wildlife Research Center-Staff Publications.*

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Ohdachi S. & Aoi T. 1987: Food habits of brown bears in Hokkaido, Japan. In: Zager P. (ed.), A selection of papers from the 7th International Conference on Bear Research and Management, Williamsburg, Virginia, USA, and Plitvice Lakes, Yugoslavia, February and March 1986. *International Association for Bear Research and Management: 215–220.*

Olah B., Boltižiar M. & Petrovič F. 2006: Land use changes' relation to georelief and distance in the East Carpathians Biosphere Reserve. *Ekológia 25: 68–81.*

Paralikidis N.P., Papageorgiou N.K., Kontsiotis V.J. & Tsiompanoudis A.C. 2010: The dietary habits of the brown bear (*Ursus arctos*) in western Greece. *Mamm. Biol. 75: 29–35.*

Pazhetnov V.S. 1990: Brown bear. *Agropromizdat, Moscov. (in Russian)*

Persson L.I., Wikan S., Swenson E.J. & Mysterud I. 2001: The diet of the brown bear (*Ursus arctos*) in the Pasvik Valley, northeastern Norway. *Wildlife Biol. 7: 27–37.*

Rigg R. & Gorman M. 2005: Diet of brown bears (*Ursus arctos*): new results from the Tatras region and comparison of the research methods. *Výskum a ochrana cicavcov na Slovensku 7: 61–79. (in Slovak with English abstract)*

Sabadoš K. & Šimiak M. 1981: Distribution and hunting management of the brown bear (*Ursus arctos* L.) in Slovakia. *Folia Venatoria 10–11: 15–32. (in Slovak with English summary)*

Selva N., Zwijacz-Kozica T., Sergiel A., Olszańska A. & Zieba F. 2011: State, ecology and management of the brown bear population in Poland. *Załącznik nr 1 do Programu Ochrony Niedźwiedzia Brunatnego w Polsce. (in Polish)*

Sidorovich V.E. 2006: Ecological studies on brown bear (*Ursus arctos*) in Belarus: distribution, population trends and dietary structure. *Acta Zool. Lituanica 16: 185–190.*

Slobodyan A.A. 1976: The European brown bear in the Carpathians. In: Pelton M.R., Lentfer J.W. & Folk G.E. (eds.), A selection of papers from the 3rd International Conference on Bear Research and Management, Binghamton, N.Y., USA & Moscow, U.S.S.R., June 1974. *International Association for Bear Research and Management: 313–319.*

Snedecor G.W. & Cochran W.G. 1980: Statistical methods, 7th ed. *Ames., Iowa State University Press.*

Straka M., Finďo S., Štofik J. & Paule L. 2009: The use of faecal and hair samples in study of brown bear populations. *Acta Facultatis Forestalis 51 (Suppl. 1): 19–29. (in Slovak with English abstract)*

Straka M., Paule L., Ionescu O., Štofik J. & Adamec M. 2012: Microsatellite diversity and structure of Carpathian brown bears (*Ursus arctos*): consequences of human caused fragmentation. *Conserv. Genet. 13: 153–164.*

Swenson J.E., Jansson A., Riig R. & Sandegren F. 1999: Bears and ants: myrmecophagy by brown bears in central Scandinavia. *Can. J. Zool. 77: 551–561.*

Swenson J.E., Sandegren F., Brunberg S. & Wabakken P. 1997: Winter den abandonment by brown bears *Ursus arctos*: causes and consequences. *Wildlife Biol. 3: 35–38.*

Štofik J. & Saniga M. 2012: Dens and beds of the brown bear *Ursus arctos* in the Eastern Carpatian region – Poloniny National Park. *Folia oecol. 39: 147–154.*

Štofik J., Buraľ M., Paule L. & Straka M. 2010: Historical survey of enlargement of brown bear (*Ursus arctos*) in the territory of Bukovske hills and adjacent territories. *Natura Carpatica 51: 65–74. (in Slovak with English summary)*

Šťastný P. 1988: Climate. In: Vološčuk I. (ed.), The Eastern Carpathians. *Príroda, Bratislava: 35–40. (in Slovak)*

Tichý L. 1999-2007: JUICE 6.5. *Institut of Botany and Zoology, Masaryk University, Brno.*

Tsachalidis E.P. & Hadjisterkotis E. 2008: Wild boar hunting and socioeconomic trends in Northern Greece, 1993-2002. *Eur. J. Wildlife Res. 54: 643–649.*

USDA 2007: USDA national nutrient database for standard reference. Release 21 nutrient data laboratory home page, accessed 31.8.2012. *http://wwwarsusdagov/nutrientdata*

Valière N. 2002: GIMLET: a computer program for analyzing genetic individual identification data. *Mol. Ecol. Notes 2: 377–379.*

Valière N. 2003: GIMLET v.1.3.2 Guide. *Laboratoire de Biométrie et Biologie Evolutive – UMR5558 – 43, boulevard du 11 novembre 1918 – F69622, Villeurbanne, France.*

Vulla E., Hobson K.A., Korstel M., Leht M., Martin A.J., Lind A., Männil P., Valdmann H. & Saarma U. 2009: Carnivory is positively correlated with latitude among omnivorous mammals: evidence from brown bears, badgers and pine martens. *Ann. Zool. Fenn. 46: 395–415.*

VUP 1996-2002: VUP Food Research Institute, Slovak food composition data bank, accessed 31.8.2012. *http://www.pbd-online.sk/#P000201*

Siegltrum G.J. & Nolte D.L. 1995: Black bear damage management in Washington state. *7th Eastern Wildlife Damage Management Conference 7: 104–107.*

Zyśk-Gorczyńska E. & Jakubiec Z. 2010: The feeding of the brown bear *Ursus arctos* on fir in the Polish Carpathian Mountains. *Chrońmy Przyr. Ojcz. 66: 71–75. (in Polish with English summary)*

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