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SHORT COMMUNICATION

Diet of wolves *Canis lupus* returning to Hungary

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Abstract At the end of the nineteenth century, the wolf *Canis lupus* was extinct in Hungary and in recent decades has returned to the northern highland area of the country. The diet of wolves living in groups in Aggteleki National Park was investigated using scat analysis (n=81 scats) and prey remains (n=31 carcasses). Throughout the year wolves (average, minimum two wolves per year) consumed mostly wild-living ungulates (mean percent of biomass consumed, B% 97.2%; relative frequency of occurrence, %O 74.0%). The wild boar *Sus scrofa* was the most common prey item found in wolf scat (%B 35.6%) and is also the most commonly occurring ungulate in the study areas. The second most commonly occurring prey item in wolf scat was red deer *Cervus elaphus* (B% 32.8%). Conversely, prey remain analyses revealed wild boar as the second most commonly utilised prey species (%O 16.1%) after red deer (%O 67.7%). The roe deer *Capreolus capreolus* that occurs at lower population densities was the third most commonly utilised prey species. The importance of low population density mouflon *Ovis aries*, livestock and other food types was low. The results are similar to those found in the northern part of the Carpathian Mountains.

Keywords Wolf · Ungulate · Predation · Scat analysis · Prey · Hungary

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As a result of persecution and changes to its habitat, the grey wolf *Canis lupus* L. became extinct in Hungary by the end of the nineteenth century. After populations increased in the Carpathians (Boitani 2000; Nowak et al. 2008), the wolf started to return to the Hungarian highland areas close to the Slovakian border during the 1980s (Faragó 1989; Szemethy and Márkus 2007; Hausknecht et al. 2010). The wolf has a wide food spectrum and is an opportunistic predator depending on the group and the body size of the prey and the structure of ungulate communities (Okarma 1995; Mech and Boitani 2003). Wolf diet is also influenced by their population size, the season and the availability of other resources associated with humans like garbage, rubbish dumps and livestock (Okarma et al. 1995; Salvador and Abad 1987; Ansorge et al. 2006; Gula 2008; Iliopoulos et al. 2009). Throughout all seasons, the main diet of group-living wolves in the forested areas of the Carpathians is wild ungulates (Lesniewicz and Perzanowski 1989; Smietana and Klimek 1993; Nowak et al. 2005). The aim of this study was to examine the dietary composition and feeding habits of the wolf that has returned to the Northern Middle Mountains of Hungary.

The study area is located in the Aggteleki National Park (northeastern Hungary, from N 48°28 E 20°29 to N 48°34 E 20°50, 135 km^2), bounded with Aggtelek, Jósvafő and Szín in the karst area between the Bódva river and the national border. The vegetation is dominated by forest (68.5%) consisting of mixed hornbeam-oak forest *Carpinus*

betulus, *Quercus petraea* (51.4%), other oaks *Quercus* spp. (29.3%), beech *Fagus sylvatica* (12.4%) and pine *Pinus* spp. (5.9%) forests. Ploughlands (29.5%), wetlands (0.5%) and grasslands (1.4%) are also present in the study area. The average elevation of this middle mountain area is 605 m with a temperate, humid continental climate. During the study (from December 2000 to February 2005), the mean average winter (December–February) temperature ranged between 0.7°C (in 2000/2001) and −3.1°C (in 2002/2003). The duration of snow cover ranged between 27 days (in 2000/2001) and 49 days (in 2002/2003), and snow depth varied between 6 mm (in 2003/2004) and 21 mm (in 2002/2003). Mean summer (June–August) temperature was 20.7±0.45°C, and annual precipitation was between 513 mm (in 2003) and 782 mm (in 2005). Throughout the year, a herd of free ranging horses lived on the meadow of the National Park without human supervision. Average human population density was 28 inhabitants per square kilometre. A small number of cattle and small stock (e.g. poultry) were kept in the villages. Minimum ungulate abundance (individual per square kilometre, mean±SE) between 2000 and 2005 was estimated using annual summarized hunting bag data (official game management harvesting data base) as follows: red deer *Cervus elaphus* 0.61±0.03, roe deer *Capreolus capreolus* 0.24±0.02, wild boar *Sus scrofa* 1.58±0.13 and mouflon *Ovis aries* 0.04±0.03.

Minimum wolf presence in the study area was confirmed as follows: 2000/2001: one wolf, 2002: two wolves including a cub, 2003: two wolves, 2004: four or five wolves including cubs and in 2005: three wolves were observed. The detection of wolf cubs (Ansorge et al. 2006) allowed us to conclude that there was at least one breeding family present in the study area (Hausknecht et al. 2010), and thus, a regular presence of wolves (average, minimum two wolves per year) during the period. The actual population size is likely to be similar to the average pack size (2–7) in Europe (review: Jędrzejewski et al. 2007) and never exceeded ten individuals (tracked in snow; Szabó Á, observations).

Dietary composition of the wolf was studied by analysis of scats collected on forest paths and along wolf tracks within the study area by experienced and field-trained personnel. Food remains from the scats including feather, bone, teeth and hair were analysed microscopically using standard procedures (Jędrzejewska and Jędrzejewski 1998). All dry food remains were weighed and multiplied by coefficients of digestibility described for wolves (Jędrzejewska and Jędrzejewski 1998) to obtain the estimate of the percentage fresh weight (biomass) of food consumed. Trophic niche breadth was calculated as described by Levins and standardized (Krebs 1989). The 12 food taxa used in these calculations are presented in Table 1 (two categories of wild boars were summarized). Wolf preference for ungulate species was calculated using the Jacobs (1974) preference index (*D*) as used in other studies (Jędrzejewska and Jędrzejewski 1998; Hayward and Kerley 2005; Nowak et al. 2005; Ansorge et al. 2006). Data on fresh prey remains were collected opportunistically during the whole year by following wolf tracks in snow and mud within the study area. Wolf predation was distinguished from scavenging by following ungulate and wolf tracks, searching for typical bite marks on

Table 1 Dietary composition of the wolf in NE Hungary

Food items	Winter		Spring		Autumn		Annual
	N	%B	*N*	%B	*N*	%B	%B
Wild boar (*Sus scrofa*)	9	27.7	18	20.3	3	32.2	26.7
Wild boar (*Sus scrofa*) young	4	13.3	5	13.4			8.9
Red deer (*Cervus elaphus*)	8	40.0	16	52.2	2	6.2	32.8
Roe deer (*Capreolus capreolus*)	6	17.1	6	7.9	5	43.4	22.8
Undetermined cervids			1	2.5	2	5.9	2.8
Mouflon (*Ovis aries*)			2	3.2	4	6.4	3.2
Cattle (*Bos primigenius*) carcass					1	5.9	2.0
Apodemus sp.	2	1.2	5	0.6			0.6
Marten (*Martes* sp.)	1	0.4					0.1
Birds (Aves)	1	+					+
Beetles (Coleoptera)			1	+	1	+	+
Fruits	4	0.1	1	+	1	+	0.1
Other plants	6	0.2	1	+	7	0.1	+
Number of items	41		56		26		123
Number of samples	24		43		14		81
B_{sta}		0.20		0.17		0.25	0.27

Scat samples collected between December 2000 and February 2005. Empty cells mean that the given taxon was not detected

N number of items in each taxa, *%B* percentage of biomass of each food item consumed, + biomass under 0.05%, B_{sta} standardized trophic niche breadth value

the carcass and noting the parts eaten from carcasses (e.g. Jędrzejewska and Jędrzejewski 1998).

Differences between seasons and years were examined on the basis of the main 12 food categories using a chi-square test and ANCOVA (dependent variable: biomass of each animal food type, namely weight of food remains × digestibility factor; independent variables: season or year and covariate: food type; SPSS 10.0 1999).

A total of 123 food items were identified in 81 wolf scats. Wild ungulates dominated the diet with domestic animals, small mammals and other food items being less important. This is similar to results found in several areas of central Europe, near the study area in the northern part of the Carpathian Mountains (Lesniewicz and Perzanowski 1989; Smietana and Klimek 1993; Okarma 1995; Nowak et al. 2005).

Neither the distribution of food items (chi-square test: $\chi^2_{33}=38.50$, $p=0.236$) nor the estimated biomass of ingested food (ANCOVA: $F_3=1.42$, $p=0.220$) differed significantly between years. However, the distribution of food items was significantly different between seasons ($\chi^2_{22}=44.67$, $p<0.01$), but this was not reflected in the estimated biomass of ingested food ($F_2=1.31$, $p=0.285$). In the wolf scat samples, the largest biomass proportion was the wild boar (Table 1) reflecting its higher occurrence in the ungulate community. Generally wild boar consumption was balanced between seasons (26.5–32.2%, Table 1) and consumed in higher proportions in years with milder winters. Scat (Table 1) and prey remains analyses (Table 2) showed wild boar as the secondary prey item of the wolf. Although adult wild boars (boar and sow) are a dangerous prey item for wolves (Jędrzejewski et al. 1992), they were preyed upon in all seasons by wolves that hunted in pairs or in groups. It is known that, independently of season, wolves select young, old or sick ungulates (Jędrzejewski et al. 1992; Głowaciński and Profus 1997).

Table 2 Species composition of wolf prey found between 2001 and 2005 in NE Hungary

Prey species, sex, age class	Prey found		Season
	N	%	
Wild boar	5	16.1	
Boar	2		Wi, Sp
Piglet or young	2		Wi
Unidentified	1		Wi
Red deer	21	67.7	
Stag	1		Au
Hind	4		Wi (2), Sp, Su
Fawn or hearst	7		Wi (3), Sp (3), Su
Unidentified	9		Wi (8), Sp
Roe deer	4	12.9	
Doe	2		Wi, Su
Unidentified	2		Wi
Mouflon	1	3.2	Wi
Total	31		

Number of cases is in brackets

Wi winter, *Sp* spring, *Su* summer, *Au* autumn

Wolf prey remains showed that wild boars were consumed in spring and winter and were mainly in bad condition (authors' observations). Yearling boars were consumed in winter while yearlings and piglets were consumed in spring. In autumn and winter, wild boar numbers are managed through intensive culling. This results in an increase in available carrion in the field and will likely increase consumption of boar through scavenging. Red deer, which live in a relatively low density in the study area, made up the second largest part of the whole biomass consumed by wolves. However, the scat (Table 1) and prey remains analyses (Table 2) showed that the red deer was the most frequent prey species preyed on by the wolf. The consumption of red deer decreased from winter (B% 60.4%) to autumn (B% 9.2%) and was the highest (B% 90.0%) in the long winter of 2002/2003. Eleven of the red deer (Table 2) predation events recorded were during this long winter. Most of the scats collected in spring (13 of 16) contained remains of red deer and were collected before the calving period (in March and the beginning of April), and calves were found in the prey remains during spring and summer. Hinds were consumed throughout the year, while deer stags (probably injured by hunters) were consumed in autumn, which is during and after the rutting and hunting season.

Wolves hunting in smaller packs (four to five members) prefer wild boar piglets and young deer while larger packs more often kill large-body-sized red deer, which is the most frequently utilised wild prey in most areas of Europe and secondly the roe deer (Okarma 1995; Jędrzejewski et al. 2002). In this study, the roe deer was only the third most important prey species and its consumption increased from winter and spring to autumn (Table 1). Most of the scats collected in spring (five of six) contained remains of roe deer that were collected before the calving period (in March and at the beginning of April). At the same time, roe deer prey remains were found in winter (three occasions) and in summer (one occasion). Consumption of low density mouflon occurred in the spring and in the autumn (Table 1) and in the winter of 2002/2003.

Preference indices were almost zero in the case of both wild boar ($D=0.005$), red deer ($D=0.005$), roe deer ($D=-0.030$) and mouflon ($D=-0.335$). Contrary to our results, in the Carpathians (Nowak et al. 2005) and in the Bialowieza forest (Jędrzejewski et al. 2000), where wolf presence was stable, wolves preferred red deer and less preferred (avoided) roe deer and wild boar. In Germany (Ansorge et al. 2006),

similarly to our study, where the wolf is also a returning top order predator, wolves showed preference for roe deer and avoidance for wild boar.

In our study, consumption of domestic animals was occasionally noted and was contributed to the low availability of this food type. While the wolves regularly utilised the meadow where the horses are kept, they were no recorded incidents of the wolves attacking the horses. Cattle were only found in the autumn diet, and this was contributed to scavenging (B% 5.9%). Occurrence of livestock consumption in this study is lower than that recorded in other central European studies (Smietana and Klimek 1993; Gula 2008) and much lower than in studies in southern Europe, where livestock production is important, and wolves may depend heavily on livestock as a food source (Salvador and Abad 1987; Iliopoulos et al. 2009). Predation on non-ungulate prey species (Table 1) was infrequent as found in other central European studies (Lesniewicz and Perzanowski 1989; Jędrzejewski et al. 1992; Smietana and Klimek 1993; Okarma 1995; Ansorge et al. 2006). No predation on lagomorphs was found in this study where the European brown hare *Lepus europaeus* is rare, while in the northern region of Europe (Gade-Jørgensen and Stagegaard 2000) and in Mediterranean areas (Salvador and Abad 1987), lagomorphs were a seasonally important food for wolves. The plant consumption of the wolf was not considerable but consisted of plum *Prunus domestica*, pear *Pyrus* spp., blackthorn *Prunus spinosa*, acorn scrap *Quercus* spp., grass Gramineae, unidentified seeds and pine *Pinus* spp. needles with the latter almost certainly being ingested accidentally along with prey items that were resting on the ground on top of pine needles. While wolves in this study utilised a broad spectrum of food, the standardized trophic niche was relatively narrow (Table 1) as was found in other studies (Okarma 1995; Jędrzejewska and Jędrzejewski 1998).

In conclusion, the main food items of the wolf returning to forested mountainous area of NE Hungary consisted mainly of wild ungulates throughout all seasons. This is comparable to results found in other studies in Europe (Peterson and Ciucci 2003). The order of importance of wild ungulates was wild boar and red deer followed by roe deer and mouflon which roughly follows their density based on hunting bag data; however, the order is largely dependent on season (e.g. calving, carrion availability). Preference indices around zero show that wolves in this study did not select for ungulate species that were available in high abundance. Consumption of livestock and other food types was not considerable. More studies are required to define if the wolf population in Gömör-Tornai karst (on either side of the border) or in other parts of the country has an effect on the populations of wild ungulates.

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