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Importance of slaughter waste in winter diet of wolves (*Canis lupus*) in Serbia

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Abstract. Winter diet composition of wolves (*Canis lupus*) in Serbia was studied by analysing the stomach contents of 111 specimens collected from 2004 to 2014. Domestic animal remains dominated in wolf diet with 79.4 % of the total biomass consumed (B) and with the frequency of occurrence (O) of 70.2 %, of which domestic ungulates made up to 66.3 % of the total biomass consumed and 61.3% of the frequency of occurrence. Its natural prey included roe deer (*Capreolus capreolus*) (12.2 % B, 7.26 % O) and wild boar (*Sus scrofa*) (7 % B, 12.9 % O). A relatively high percentage of dogs (*Canis lupus familiaris*) was recorded (8 % B, 6.4 % O). No significant differences were observed in the diet of subadult and adult wolves (% B: G=15.83, p=0.071; % O: G=17.18, p=0.103). There was no difference in the amount of food consumed considering sex or age (sex: t=0.52, p=0.608; age: t=0.37, p=0.715). Like in many studies conducted in South Europe, our results show large dependence on anthropogenic food sources.

Key words: wolf, *Canis lupus*, winter, diet, stomach analysis, Serbia.

Introduction

The wolf (*Canis lupus*) is one of the three large carnivore species in Serbia. This widespread carnivore inhabits mountain forested regions in western, eastern, and southern parts of the country (Fig. 1). Along the Velika Morava River valley (the central part of Serbia), wolves are absent or occasionally present. In addition to mountain regions of central Serbia, a small isolated population inhabits the south-eastern part of the Pannonian Plain in the Vojvodina province (Milenković 1997, Milenković et al. 2007, 2010).

The wolf is a strictly protected species only in a smaller part of its range in Serbia, namely in Vojvodina. In the rest of its range it is a game species without protection (without a closed season). Recently estimated population size is 700-800 individuals, and the population trend is characterized as stable or slowly increasing (Milenković et al. 2007). The annual harvesting is 200 wolves on average, which makes 25-28 % of the estimated population size.

Feeding and foraging ecology of wolves is the most important component for a better understanding of their role in population dynamics and structure of prey species, functioning of inhabited ecosystems, and possible conflicts with humans. Many studies have been conducted in this field in Europe. Wolves are described as generalist predators whose diet vary from wild herbivores (Andersone & Ozoliņš 2004, Ansorge et al. 2006, Meriggi et al. 2011, Nowak et al. 2011, Jedrzejewski et al. 2012, Lanszki et al. 2012), medium and small mammals (Castroviejo et al. 1975) to livestock (Fico et al. 1993, Vos 2000, Iliopoulos et al. 2009, Magrini 2014), carrion, and rubbish (Macdonald et al. 1980). But in the region of the Balkan Peninsula, data on wolf feeding ecology is almost completely missing. Except for a few published results from Greece (Papageorgiou et al. 1994, Migli et al. 2005, Georgiev et al. 2008, Iliopoulos et al. 2009) and several conference papers from Bulgaria (see Zlatanova et al. 2014) and Slovenia (Krofel & Kos 2010), there is no information regarding the feeding ecology and foraging behaviour of wolves in this part of Europe.

The aim of this study was to examine the diet composition of wolves during the winter period that can be very disadvantageous due to the snow coverage and limited food availability. These are the first results on feeding habits of wolves in Serbia, given that no similar studies have been conducted so far.

Material and Methods

Stomach collecting

The winter diet study of wolves in Serbia was conducted during the period 2004-2014 and based on the analysis of the stomach contents. Bodies of 111 specimens (65 males and 46 females) were collected in cooperation with local hunting organizations for 11 winter seasons (December–February) throughout the Serbian part of the wolf distribution range (expect one vagrant specimen). Common hunting practices in Serbia include driven hunt, tracking and stalking, high seat-baiting while practices such as spotlighting and snares are forbidden. Samples for this study were originated from 27 localities (Fig. 1). For each animal, sex, date of death, the most precise locality, standard

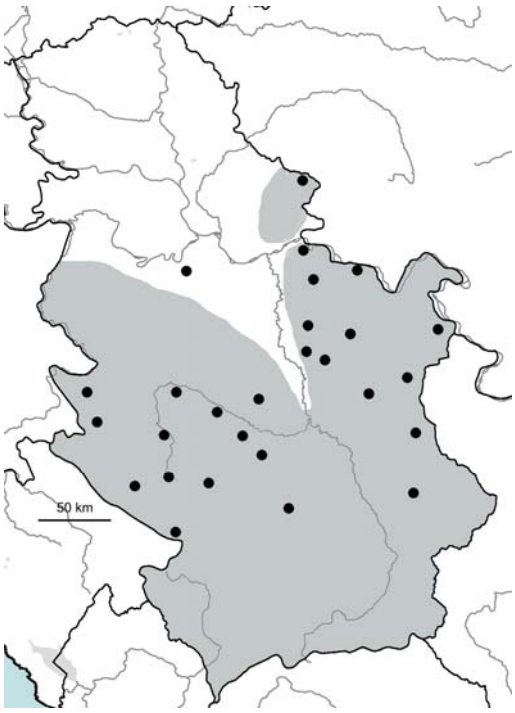

Figure 1. Localities where the samples were collected. Shaded area represents wolf distribution range in Serbia.

body parameters (body mass, body length with head, tail length, hind foot length, ear length, and height at the shoulder) and age (yearlings or adults) were noted. The age was determined according to the body size, as well as using the tooth wear criteria (Lombaard 1971). We analysed 51 adults and 45 subadults with stomach contents. After taking the morphometric measurements, stomachs with intestines were extracted and preserved in a deep freezer (-20 °C) prior to laboratory processing.

Identification of food items

Frozen stomachs were thawed and processed using the standard procedure (Roper & Lüps 1995; Ćirović et al. 2014) - the stomachs were opened, the content was removed and measured with an accuracy of 1g. The content was then examined macroscopically and the remains were categorized into predetermined food categories. Each food category was weighted separately and rinsed off with a water jet, using sieves with mesh openings of 0.5 mm. Teeth, jaws, parts of skulls (from small mammals), and hair were isolated, in order to facilitate identification. The collected osteological material was cleaned of the remaining tissue, bleached with 10% solution of hydrogen peroxide, rinsed, air-dried at a room temperature, and stored until final identification. Hairs were washed with 70% ethanol, air-dried at room temperature, and stored until final microscopic identification.

The hairs were studied under the magnification of 400x, using the procedure suggested by Teerink (1991) and identified using reference guides (Day 1966, Teerink 1991, De Marinis & Agnelli 1993) and our own reference collection. The osteological material was identified using the identification keys for the local mammal fauna (Mirić 1970; Kryštufek 1999) as well as the comparative mammal collection of the Faculty of Biology, University of Belgrade. All collected remains were identified to the lowest recognizable taxon.

Diet composition and statistical analyses

Identified food items were classified into 13 food categories: cow, pig, sheep, goat, chicken, turkey, dogs, plant (leaves and grass), roe deer, wild boar, European hare, small mammals (*Microtus* sp.), and indigestible materials (nylon, plastic bags, aluminium foil, etc). In order to make the interpretation of the results easier, cow, pig, sheep, goat, dog, chicken and turkey were additionally merged under the domestic animal food category, while roe deer, wild boar, and European hare were merged under the game species food category. Small mammals, plant and indigestible materials were categorized as other food.

The diet composition was expressed in two forms: as the relative frequency of occurrence (% O – number of occurrences of a certain food category divided by the total number of occurrences of all food categories and then multiplied by 100) and the percentage of biomass consumed (% B – wet weight mass (g) of a food category divided by total mass of all food categories and then multiplied by 100). The relative frequency of occurrence and the percentage of biomass consumed were calculated separately for each food category for subadults and adults as well as for the total sample. The frequency of occurrence gives more details about food habits, and emphasise the importance of infrequent and small-sized food items. Opposite to frequency of occurrence, the percentage of biomass consumed accentuates the role of larger prey in the predator's diet or the type of food which is consumed in larger quantities.

Statistical analyses were used to test the differences in the wolf diet during winter periods. Differences in the amount of food consumed by each sex and age were tested using the Student's t-test. For further analyses we used non-parametric statistical tests, as the data did not follow the normal distribution. In order to detect the differences in wolf diet between subadults and adults for % B and % O, we used the G-test (Sokal & Rohlf 1995). The only item that was not included in the non-parametric testing was the indigestible material. All analyses were conducted using Statistica 5.1 (Statsoft, Tulsa, OK, USA).

Results

From 111 collected stomachs, 15 (13.5 %) were empty and were therefore excluded from further analysis (Table 1). The average weight of the stomach contents was 679.8±606.7 g (males 706.8±659.9, females 641.9±529.2). The largest quantity of consumed items was 2813 g. The analysis of the amount of ingested food regarding sex and age (adults and subadults) revealed no statistically significant differences (sex: t=0.52, p=0.608; age: t=0.37, p=0.715).

The main food sources for wolves in Serbia during the winter period were livestock remains, which represented 66.3 % B and 61.28 % O of the total diet (Table 1). All domestic animals (poultry, livestock, and dogs) were represented in large amounts and frequencies (79.42 % B and 70.16 % O). Of all domestic animals in the winter diet, the most important food sources were cows (45.73 % B and 31.45 % O) and pigs (13.68 % B and 21.77 % O). The domestic animal category was mostly represented (more than 90 %) with the remains of these animals (skin, intestine, fat, intestinal organs, etc.), presumably left at the irregular dumps after slaughtering. Only in a few cases we can confirm that domestic animals were wolf prey, when we found as well muscle tissue and bones. Regarding the consumed biomass, dogs were on

Table 1. Winter (December - February) diet composition of wolves in Serbia during the period 2004-2014. (Legend: % B – frequency of biomass consumed, % O – frequency of occurrence of food taxa)

		Subadults		Adults		Total	
	Food taxa	% B	% O	% B	% O	% B	% O
Domestic animal remains	Cow	50.69	36.21	41.54	26.87	45.73	31.45
	Pig	14.16	20.69	13.27	23.88	13.68	21.77
	Dog	1.80	5.17	13.28	7.46	8.01	6.45
	Sheep	6.04	3.45	6.27	8.96	6.16	6.45
	Goat	0.00	0.00	1.35	2.99	0.73	1.61
	Turkey	5.85	1.72	4.46	1.49	5.10	1.61
	Chicken	0.00	0.00	0.00	1.49	0.00	0.81
Game animals	Roe deer	10.64	5.17	13.54	8.96	12.21	7.26
	Wild boar	9.92	13.79	4.48	11.94	6.98	12.90
	European brown hare	0.00	0.00	1.72	1.49	0.93	0.81
Other food	Plant material	0.58	6.90	0.08	4.48	0.31	5.65
	Small mammals	0.07	3.45	0	0	0.03	1.61
	Indigestible	0.26	3.45	0	0	0.12	1.61

the fourth place in the wolf diet (8.01 %). Moreover, regarding the frequency of occurrence, dogs were as frequent as sheep in its diet (6.45 %).

Game animals (roe deer, wild boar and European hare) were represented in total with 20% in the wolf diet (20.12 % B and 20.97 % O). Regarding the % B, the most important was the roe deer (12.21 %), while regarding the % O, it was the wild boar (12.9 %). European hare was of lesser importance, since it was found only once.

Other food categories had a low importance in the wolf diet. Wolves use plant material in their winter diet quite often (5.65 % O), but in small quantities (0.31 % B). *Microtus* species were found only as sporadic prey in the wolf diet during winter (Table 1).

Although slight differences in % B and % O were recorded between the subadults and adults (Table 1), these differences were not statistically significant as indicated by the G test (% B: G=15.825, p<0.071; % O: G=17.175, p<0.103).

Discussion

Many studies conducted throughout Europe showed that wild ungulates are the main food sources for wolves in all seasons (Okarma 1995, Jedrzejewski et al. 2012, Lanszki et al. 2012). Some studies from southern Europe indicate that domestic ungulates are the most important food source (Fico et al. 1993, Meriggi & Lovari 1996, Meriggi et al. 1996, Vos 2000, Iliopoulos et al. 2009, Magrini 2014). In general, wolf feeding strategy depends on the availability of wild ungulates as its natural prey (Mattioli et al. 1995). When high population densities of wild ungulates occur in a habitat, in that case they will represent the main prey of wolf (Meriggi et al. 2011). But in habitats with low wild ungulate densities, wolves use food which is easier to get, such as domestic ungulates or carrion, garbage, and fruits (Salvador & Abad 1987, Papageorgiou et al. 1994, Meriggi et al. 1996, Migli et al. 2005, Iliopoulos et al. 2009).

Feeding habits of wolves in Serbia during the winter period signify their opportunistic behaviour oriented to easily available and abundant anthropogenic food sources. In this study, the main food source for wolves was the remains of domestic animals. After slaughter, viscera are commonly left at irregular dumps (due to non-compliance with sanitary regulations). At these places, large amounts of domestic animal remains (mainly skins and intestines) can be found. Also, livestock carcasses could be found occasionally in some hunting grounds on artificial feeding stations. In this way, local people or hunters provide plenty amount of food of anthropogenic origin. Studies conducted in southern Europe suggest similar results: in Italy (Fico et al. 1993, Meriggi et al. 1996, Magrini 2014), Portugal (Vos 2000, Torres et al. 2015) and Greece (Papageorgiou et al. 1994, Migli et al. 2005), livestock was also the dominant food category, same as in our study. It is known that in areas where the diversity of wild ungulates is not rich, and the habitats are anthropogenically-modified, wolves feed primarily on livestock and smaller prey (Papageorgiou et al. 1994, Sidorovich et al. 2003, Zlatanova et al. 2014). Contrary to these findings, in central, eastern, and northern Europe, large and rich communities of wild ungulates are present and represent the main food category for wolf packs (Okarma 1995, Gade-Jørgensen & Stagegaard 2000, Andersone & Ozoliņš 2004, Ansorge et al. 2006, Žunna et al. 2009, Nowak et al. 2011, Jedrzejewski et al. 2012, Lanszki et al. 2012).

We can make a conclusion that the high levels of livestock consumption could be a result of low diversity and density of wild ungulates in research areas. Regarding wild ungulates, most common species in wolf diet were roe deer and wild boar, which are in general the most common wild ungulate species in Serbia. The proportions of roe deer and wild boar in this study were generally lower than in other published studies from central and eastern Europe (Andersone et al. 2004, Ansorge et al. 2006, Jedrzejewski et al. 2012, Lanszki et al. 2012), but similar or lower than in Greece (Papageorgiou et al. 1994, Migli et al. 2005) and some parts of Italy (Meriggi et al. 1996). Opposite to many other studies (especially from central, eastern, and northern Europe, see Okarma 1995, Ansorge et al. 2006, Jedrzejewski et al. 2012, Lanszki et al. 2012), in which red deer was one of the most important prey species, it was not present in this study. It is most likely because the red deer is present only locally within the distribution range of the wolf.

Dogs were present as a prey in the wolf diet. Although there were many reports regarding damages on owned dogs (purebred hunting dogs) during the study period, we can not say with certainty whether the dogs were owned or stray. High percentage of dogs in wolf diet is also recorded in some parts of Spain (Cuesta et al. 1991) and Belarus (Sidorovich et al. 2003) as well. In other studies dogs were found only in few cases or in small proportions, regardless of season (Gade-Jørgensen & Stagegaard 2000, Vos 2000, Valdmann et al. 2004, Valdmann et al. 2005, Barja 2009).

This study is the first description of food habits and feeding behaviour of the wolves in this part of its European distribution range, where information was lacking. In order to better understand the trophic ecology of wolves in Serbia, further research needs to include all seasons. It could be based on stomach content analyses or scat analyses, combined with a search for kill remains of wild ungulates and with monitoring of depredation (damages) of livestock.

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