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Interprovinciaal Overleg

uw brief van	uw kenmerk	ons kenmerk	datum
		VP 08710/2019	15 januari 2019

onderwerp
Wettelijke bescherming Goudjakhals

Geachte [redacted]

Op 3 oktober 2018 heeft een afvaardiging van IPO/provincies ambtelijk overleg met u gevoerd over de wolf in Nederland. In dit gesprek is ook aandacht gevraagd voor de Goudjakhals (Canis aureus), het 'kleine neefje van de wolf', die inmiddels eveneens op eigen kracht zijn verspreidingsgebied aan het uitbreiden is en ons land heeft bereikt.

De Goudjakhals is opgenomen in bijlage V van de EU-Habitatrichtlijn, maar valt momenteel nog niet onder het beschermingsregime van de Wet natuurbescherming (Wnb). Het vaststellen van de wettelijke beschermde status van de Goudjakhals op grond van de Wnb biedt veel duidelijkheid ten aanzien van het tegemoetkomen van (te verwachten) faunaschade. Namens de provincies verzoek ik u derhalve om de Goudjakhals op te nemen als beschermde inheemse diersoort onder artikel 3.10 Wnb.

In Nederland zijn er inmiddels twee bevestigde waarnemingen van de goudjakhals. Deze passen goed in het patroon van de Europese uitbreiding.[i] De verwachting is dat het aantal meldingen in Nederland in de komende jaren zal toenemen.

Op grond van de EU-Habitatrichtlijn moeten alle soorten die genoemd zijn in de bijlagen in een gunstige staat van instandhouding gebracht en gehouden worden. Dit geldt ook voor bijlage V-soorten. Dit is bepaald in Commissiedocumenten, maar vloeit ook voort uit de richtlijn zelf. Zo kunnen bijlage V-soorten bejaagbaar worden verklaard, maar jacht mag alleen worden toegestaan onder de voorwaarde dat de gunstige staat niet in gevaar wordt gebracht. Om deze gunstige staat te waarborgen is het noodzakelijk om de soort -in dit geval de goudjakhals - een beschermde status te geven.

Inlichtingen bij : [redacted]
Doorkiesnummer :
Bijlagen : één

Omdat de soort niet is opgenomen in bijlage IV van de EU-Habitatrichtlijn, komt de soort niet in aanmerking om onder artikel 3.5 Wnb te ressorteren. Artikel 3.10 Wnb leent zich ons inziens wel om de soort de juiste beschermde status te geven, die overigens ook goed aansluit bij de basisbescherming die soorten op grond van het CBD en Verdrag van Bern toekomen. Bescherming van de goudjakhals onder artikel 3.10 Wnb past ook bij de keuze van de Nederlandse wetgever om alle inheemse zoogdieren een beschermde status te geven.

Voor de provincies is relevant dat de Goudjakhals een opportunist is, die elders goed in staat is gebleken om in de directe nabijheid van mensen te leven. Zie het als bijlage toegevoegde artikel uit Servië.
Omdat uit voedselanalyse blijkt dat de Goudjakhals zich ook met gehouden (pluim)vee voedt, is het voor de provincies van belang om bij faunaschade een tegemoetkoming te kunnen verlenen. De provinciale beleidsregels tegemoetkoming faunaschade, waarvoor BIJ12 voor de uitvoering is gemandateerd, gaan uit van een tegemoetkoming bij schade door natuurlijk in het wild levende *beschermde* dieren. Het plaatsen van de Goudjakhals onder artikel 3.10 Wnb maakt dan volstrekt duidelijk dat bij schade door deze soort een tegemoetkoming kan worden verstrekt.

Mocht u naar aanleiding van dit schrijven nadere vragen of opmerkingen hebben, dan zijn wij uiteraard steeds bereid om dit toe te lichten.

Met vriendelijke groet,
INTERPROVINCIAAL OVERLEG

[redacted]

teammanager

[i] https://link.springer.com/article/10.1007%2Fs10531-015-0948-y en www.goldschakal.at

Seasonal variation in diet of the golden jackal (Canis aureus) in Serbia

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ORIGINAL PAPER

Seasonal variation in diet of the golden jackal (*Canis aureus*) in Serbia

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Abstract Seasonal variation in diet of golden jackal in Serbia was assessed by stomach content analysis. During the period 2004–2013, 339 samples were collected at two localities—Surčin (central Serbia, 15 km west of Belgrade, along river Sava) and Veliko Gradište (northeastern Serbia, 85 km east of Belgrade, along Danube River). Jackals consumed a broad range (15) of different food categories. Seasonal differences in diet are related with the availability of certain food categories. Small mammals are the most important food category when they are most abundant—in summer and autumn regarding both frequency of occurrence and frequency of biomass consumed (32.1 %O and 36.5 %B, and 29.0 %O and 37.0 %B, respectively). Moreover, high percentage of plant material is recorded during summer (23.8 %O, 20.8 %B), consisting mainly of fruit that ripen at this time of the year. Due to presence of domestic ungulate leftovers on illegal dumps year-round, this food category is representing its staple diet. High overlap between summer and autumn as well as between winter and spring is recorded (C=0.97 and C=0.94, respectively). These findings confirm golden jackal's opportunistic nature, foraging behaviour and high dependence on human-provided food resources.

Keywords Golden jackal · *Canis aureus* · Stomach content analysis · Scavenging · Opportunism · Anthropogenic food sources

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Introduction

Golden jackal (*Canis aureus*) is a widespread medium-sized canid species. It is fairly common throughout its range which covers areas from Southeastern Europe, Northern and Eastern Africa, Arabian Peninsula, Middle East and Caucasus eastwards into Indian subcontinent and Southeast Asia (Jhala and Moehlman 2004). Its status and distribution in Europe have undergone dramatic changes during the past century (Kryštufek et al. 1997; Arnold et al. 2012). Balkan Peninsula is considered its core area of distribution in Europe (Spassov 1989; Kryštufek et al. 1997; Arnold et al. 2012; Šálek et al. 2014). Destruction of reeds and scrubland habitats together with extermination efforts (directly via persecution and indirectly via poisoned baits) that was implemented across Balkan Penninsula during the first half of the twentieth century resulted in decreased number of jackals (Spassov 1989). Scattered populations remained mainly along the Mediterranean and Black sea coasts and very few of them in the mainland of Balkan Peninsula (Kryštufek et al. 1997). After implementation of conservation measures such as declaration of this species to be protected in Bulgaria and due to abundant food sources (Markov 2012), their number increased significantly (33-fold range increase within 23 years after species being protected) (Genov and Vassilev 1989; Spassov 1989; Kryštufek et al. 1997), resulting in golden jackal being one of the most abundant canid species in Europe. Today, the highest population densities are occurring in central and eastern part of Balkan Peninsula, namely, in Bulgaria where the estimated population size is more than 39,000 specimens (Markov 2012) and in eastern part of Serbia where local densities are up to 4.8 territorial groups per square kilometre (Šálek et al. 2014). The average population density in Bulgaria, Romania, Serbia and Croatia is between 0.6 and 1.1 territorial

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groups per square kilometre (Šálek et al. 2014), in core areas of Hungary 0.2 groups/km^2 (Szabó et al. 2007), and in Greece the highest jackal population densities are up to 0.5 groups/km^2 (Giannatos et al. 2005). The range of golden jackal is currently expanding across Europe, from the Balkans towards Central and Western Europe (Kryštufek et al. 1997; Arnold et al. 2012).

Similar to that in many European countries, in Serbia, it was not a common species for a long period of time. As a side effect of large-scale poisoning activities which occurred after World War II in order to reduce the wolf population, jackal population in Serbia decreased in number (Milenković 1983, 1987). Only a small number of jackals survived, but at the beginning of 1980s, their numbers started to increase and their range to expand (Milenković 1983, 1987; Savić et al. 1995; Ćirović et al. 2014). Presently, the range of jackal in Serbia covers about two thirds of the total territory of Serbia (Ćirović et al. 2008, 2014). It is a game species that can be hunted throughout the year and it is commonly considered as a pest in hunting grounds.

Golden jackal is a social canid, but it can hunt alone, in pairs, or in group when it has better chances to catch a larger prey (Wyman 1967; Lamprecht 1978). Across its global range, jackal is considered as an omnivorous and opportunistic forager (Jhala and Moehlman 2004). Diet ranges from small mammals (Lanszki and Heltai 2002; Lanszki et al. 2010; Mukherjee et al. 2004), through livestock carcasses (Lanszki et al. 2009, 2010; Borkowski et al. 2011) to game species, mostly consumed as viscera (Bošković et al. 2013).

Data on golden jackal's diet in Serbia is limited. So far, only the winter aspect of its dietary habits was studied (Ćirović et al. 2014). Moreover, studies regarding seasonal aspects of jackal's diet in other European countries are very scarce, except several studies from Hungary (Lanszki et al. 2006, 2015; Lanszki and Heltai 2010). In the absence of more comparative studies of this kind, we investigated in which extent human activities influence diet of the golden jackal across all four seasons. The aims of this study are to analyse the diet of the golden jackal in Serbia and to determine which prey species may be affected by predation. Moreover, we wanted to test whether there are differences in their food composition across seasons which would support its status of an opportunistic forager.

Material and methods

Study area

The two chosen localities (Fig. 1) are located in a human-dominated landscape, within the core area of jackal's distribution in Serbia. Locality of Surčin is in the Srem region, one of two regions in Serbia from which jackals never disappeared (Milenković 1983, 1987; Kryštufek et al. 1997; Ćirović et al. 2008), and in Veliko Gradište, first jackals appeared at the beginning of the 1980s. Both localities are situated along two big rivers—Surčin on the Sava River and Veliko Gradište on the Danube which is recognized as one of the main colonization routes to central Europe (Zachos et al. 2009).

The climate in Serbia is temperate continental, with relatively cold and moderately humid winters, and warm and moderately dry summers. The average annual temperature is 11.5 °C in Veliko Gradište and 11 °C in Surčin. The lowest temperatures are recorded in January. The annual amount of precipitation is 623.6 mm in Veliko Gradište and 663 mm in Surčin. Snow cover occurs from November until March. The highest number of days with snow coverage occurs in January (Stevanović and Stevanović 1995). The alluvial willow (*Salix* sp.) and white poplar (*Populus alba*) forests are present along the rivers of Sava and Danube. Mixed forests, consisting predominantly of oak (*Quercus* sp.), narrow-leaved ash (*Fraxinus angustifolia*) and common hornbeam (*Carpinus betulus*), are present in higher altitudes.

Surčin is located at the outskirts of Belgrade at the elevation of 80–195 m above the sea level. The jackal bodies were collected from an area of 115 km^2. According to our unpublished data based on acoustic method, jackal average density in this area is 1.7 groups/10 km^2. It is predominantly an agricultural area (82 %) with large fields of maize (*Zea mays*), wheat (*Triticum* spp.), soybean (*Glycine max*) and sunflower (*Helianthus annuus*). Few small forested patches (6 %) can be found in this area. Other types of land are meadows and pastures (4 %), and orchards and vineyards (3 %), and approximately 5 % is abandoned land. This locality is not densely populated, with on average 2.5 settlements per 100 km^2.

Elevation of Veliko Gradište is ranging from 68 to 362 m. Jackals' bodies were collected within the hunting zone of 197 km^2. Within this area, jackal density is 1.9 groups/km^2 (Heltai et al. 2013). Agricultural land is dominant in this area (71 %), while forests cover around 10 %. Forests are patchily distributed within the matrix. In this region, pines (predominantly *Pinus nigra*) and black locust (*Robinia pseudoacacia*) were planted in order to prevent the erosion of sandy soil. Meadows and pastures cover around 7 %, and orchards and vineyards around 3 %. Approximately 8 % is abandoned land. The average number of settlements in this area is 7.6 per 100 km^2.

Regarding mammal game species at both localities, roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), European hare (*Lepus europaeus*) and red fox (*Vulpes vulpes*) are present, while at Veliko Gradište, also grey wolf (*Canis lupus*) is occasionally present and hunted. Apart from foxes and wolves, roaming dogs as potential competitors are present on both localities. From bird game species, pheasants

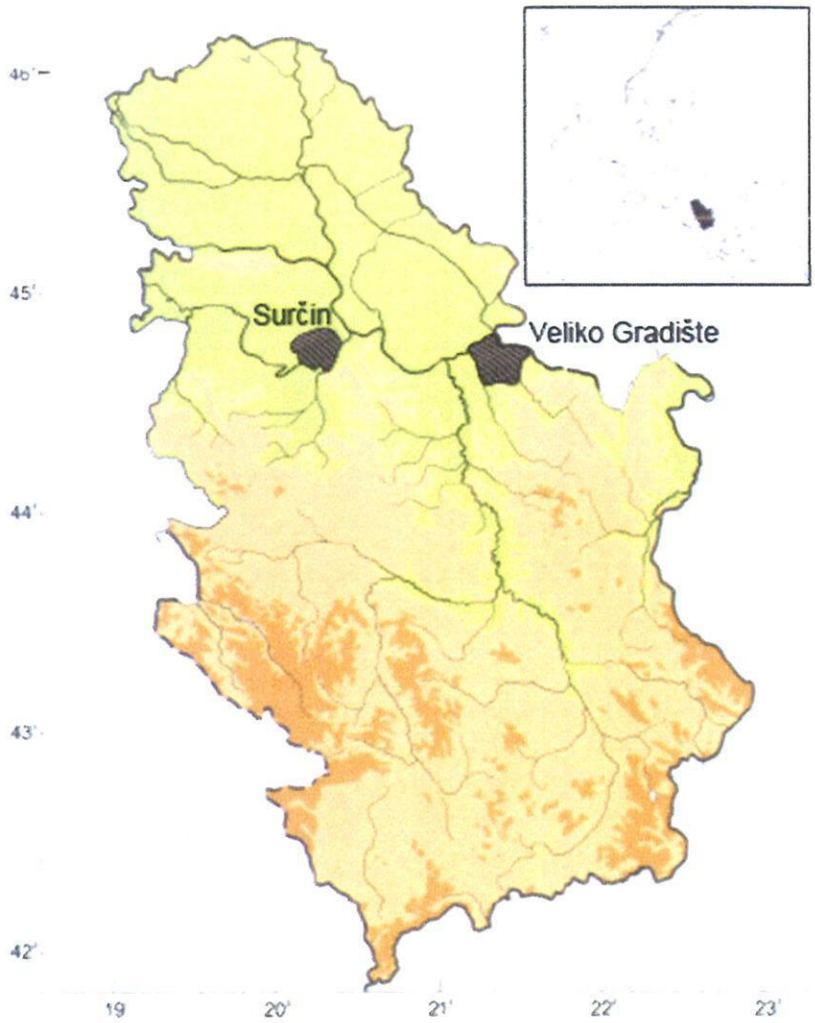

Fig. 1 Map of Serbia with two study areas—Surčin and Veliko Gradište

(*Phasianus colchicus*), common quail (*Coturnix coturnix*), wild ducks (*Anas platyrhynchos*) and grey partridge (*Perdix perdix*) are present on both localities.

According to the hunting bag data for the period 2007–2014 from Veliko Gradište, on average, 13 roe deer, 7 wild boars and 398 pheasants were shot per year. Moreover, on average, 386 brown hares were shot per year from 2007 to 2011 since then, the permanent ban of hunting is in force. In two fenced areas in Surčin, fallow deer (*Dama dama*), red deer (*Cervus elaphus*), mouflon (*Ovis aries*) and wild boar (*S. scrofa*) are abundant. Hunting bag data for Surčin study area shows that, on average, 62 wild boars, 4 roe deer, 16 red deer, 16 mouflon, 37 fallow deer, 530 hares, 1886 pheasants, 275 quails and 131 wild duck were shot annually. Common species of small mammals on both localities are as follow: common vole (*Microtus arvalis*), bank vole (*Myodes glareolus*), wood mouse (*Apodemus sylvaticus*), striped field mouse (*Apodemus agrarius*) and yellow-necked mouse (*Apodemus flavicollis*) (Petrov 1992).

Stomach collection and analyses

The most commonly used indirect methods for dietary studies of golden jackal in Europe are analyses of scat and stomach contents. Although more time is needed to obtain the samples, the main potentials of stomach content analysis are determining seasonal, age and sex differences as well as easier determination of the content due to a lower digestion rate of food consumed. For this study, golden jackal stomachs were collected during the period 2004–2013 from predator control (hunting) and road kills. During these 9 consecutive years, 339 jackal carcasses from two localities were obtained (Fig. 1). Of the total number of stomachs, 294 with content (86.7 %) were included in the analysis and 45 empty stomachs (13.3 %) were excluded. Majority of samples (149) were collected during the main hunting season in winter (Table 1). All the jackals were sexed, weighed and measured before the necropsy. Stomachs were removed from carcasses in the field and frozen (−20 °C) until the analysis. In the laboratory of Faculty of Biology, University of Belgrade, stomachs were thawed

Table 1 Frequency of occurence (%O) and percentage of biomass consumed (%B) by golden jackals across seasons and on the annual basis (expressed as mean values±standard deviation)

	Winter N=149		Spring N=45		Summer N=40		Autumn N=60		Total N=249	
Food category	%O	%B	%O	%B	%O	%B	%0	%B	%0	%B
Domestic ungulates	45.2	69.0	32.0	61.8	19.0	21.3	23.7	36.2	35.2±10.7	54.7±18.3
Poultry	12.6	9.9	9.3	6.2	2.4	1.3	4.6	4.6	9.0±4.1	7.1±3.2
Small mammals	18.0	4.8	16.0	12.7	32.1	36.5	29.0	37.0	21.9±6.1	16.9±14.6
Wild boar	4.2	3.6	2.7	1.2	2.4	1.5	3.8	5.4	3.6±0.7	3.3±1.4
Roe deer	2.9	4.6	4.0	4.6	1.2	9.8	0.0	0.0	2.2±1.4	4.4±2.8
Hare	3.8	1.4	4.0	7.3	0.0	0.0	3.1	3.3	3.1±1.3	2.5±2.3
Game birds	2.1	0.3	2.7	0.6	1.2	2.0	0.0	0.0	1.6±0.9	0.5±0.6
Other birds	2.1	0.5	5.3	0.1	2.4	0.1	5.3	0.4	3.3±1.5	0.4±0.2
Plant material	1.7	0.1	12.0	1.9	23.8	20.8	16.8	10.1	9.4±8.4	5.2±7.3
Other carnivores	0.8	4.1	0.0	0.0	1.2	0.6	2.3	2.4	1.1±0.7	2.6±1.6
Cats and dogs	2.1	1.3	2.7	1.3	1.2	2.7	1.5	0.1	1.9±0.5	1.2±0.7
Reptiles and amphibians	0.4	<0.05	2.7	0.1	1.2	0.2	0.8	<0.05	0.9±0.8	0.9±0.8
Indigestible	3.8	0.4	0.0	0.0	0.0	0.0	7.6	0.4	3.5±2.7	3.5±2.7
Invertebrates	0.0	0.0	6.7	2.3	10.7	3.2	1.5	0.0	2.8±3.9	2.8±3.9
Fish	0.4	<0.05	0.0	0.0	1.2	<0.05	0.0	0.0	0.4±0.4	0.4±0.4

N represents the number of stomach samples

and processed according the standard procedure (Roper and Lüps 1995). Stomach content was measured with the precision of 1 g. The content was examined macroscopically and divided into piles according to the food categories and then measured again. Each pile was washed through a 0.5-mm wire sieve and air-dried.

The identification of prey remains was done to the lowest possible taxon. Small mammals were identified according to teeth and hair. Hairs were microscopically examined as described in Teerink (1991) with minor modification. Osteological material was identified using the identification keys for local mammal fauna (Mirić 1970; Kryštufek 1999). Identification of birds was mainly done according to feathers. Determination of hairs and feathers was done using keys (Day 1966; Teerink 1991; De Marinis and Agnelli 1993) and our own reference collections.

Diet composition and statistical analyses

All food items were classified into 15 categories: roe deer, European brown hare, small mammals, wild boar, game birds (common pheasant and grey partridge), other birds, dogs and cats, domestic ungulates (cow, sheep, goat and pig), poultry, medium-sized carnivores (jackals, mustelids), reptiles and amphibians, fish, plant material (seeds, fruits, grass, etc.), invertebrates and indigestible material (e.g. plastics and aluminium foil).

The diet composition is defined in two ways: as relative frequency of occurrence per food item (%O) and percentage of biomass consumed (%B). The relative frequency of occurrence was calculated as the number of occurrences of a certain food category divided by the total number of occurrences of all food categories and then multiplied by 100. The percentage of biomass consumed was calculated as the wet weight mass (g) of a given food category divided by the total wet weight mass of all food categories and then multiplied by 100 (Ćirović et al. 2014; Lanszki et al. 2015). The frequency of occurrence gives more details about food habits, gives better insight in predator's ecology and highlights the importance of rare and small-sized food items. Opposite to frequency of occurrence, the percentage of biomass consumed emphasizes the role of larger prey in the predator's diet or the type of food which is consumed in larger quantities.

The relative frequency of occurrence and the percentage of biomass consumed of each food category were calculated for each season, for locality (weighted by the proportion of seasonal sample size), and on the basis of total sample size. Two-way ANOVA was used to assess the effects of sex and seasons on stomach content weight. Data were transformed using logarithmic transformation and the assumptions of models were validated through examination of the residuals. In order to detect the differences in the jackals' diet between localities and between

seasons for %O and %B, we used G-test (Sokal and Rohlf 1995). The standardized Levin's index was used to calculate the values for niche breadth of each season, applied to the proportions of food items consumed:

$$B = \frac{1}{\sum p_i^2}$$

where B is Levin's niche breadth and p_i is the proportion of a single resource category (food item) in relation to the overall consumption. Subsequently, we calculated the standardized Levin's niche breadth (B_A) as suggested by Hurlbert (1978) by computing:

$$B_A = \frac{B-1}{n-1}$$

where B_A is the standardized Levin's niche breadth, B is the Levins' measure of niche breadth, and n is the number of possible resource states (food categories). The standardized Levin's index varies between 0 (minimal niche breadth) and 1 (maximal niche breadth) (Levins 1968; Colwell and Futuyma 1971).

To compare the similarity of diet between seasons, we used Morisita's overlap index with the formula

$$C_D = \frac{2\sum_{i=1}^{S} x_i y_i}{(D_x + D_y)XY}$$

where x_i is the number of times a food category i is represented in the total X from one season and y_i is the number of times a food category i is represented in the total Y from other season. D_x and D_y are the Simpson's index values for the x and y samples, respectively. S is the number of food categories. Morisita's index varies between 0 (total separation) and 1 (total overlap) (Morisita 1959). All the analyses were conducted using Statistica 5.1 (Statsoft, Tulsa, OK, USA) and EcoMeth software, program NICHE 6.0.

Results

Based on the total sample, average stomach content (±SD) weighed 157.8±171.9 g and consisted of two food categories. The maximum number of food categories found in one stomach was 5. There was no statistically significant difference between sexes regarding number of food categories found per stomach (t=0.17, p=0.24). Results of ANOVA show that there was no effect of interaction of sex and season on stomach content weight of the total sample size (F(3,286)=0.899, p=0.442) nor that there is a main effect of sex (F(1,286)= 0.531, p=0.467), but that there is statistically significant difference in the amount of food consumed across seasons (F(3,286)=4.495, p=0.004). All 15 food categories were recorded at Veliko Gradište while game birds were not present in the diet of jackals from Surčin area. The mean value and the standard deviation for %O and %B of food categories based on the total sample are presented in Table 1. The most frequent type of food as well as the largest quantities consumed was domestic ungulates of which pigs were predominant in comparison to goats, cows and sheep. The second most consumed food category regarding both %O and %B were small mammals (22.7±6.2 %O and 16.9±14.6 %B). Vole species were dominating: they made up 82.4 % of the total biomass consumed of this category while mice (*Apodemus* sp.) comprised 7.2 % (Table 2). Poultry is consumed also in a great extent (8.5±4.1 %O and 7.1±3.2 %B) as well as plant material (10.4±8.4 %O and 5.2±7.3 %B). Wild boar, like most of roe deer and hare findings, was present only in form of skin and intestines that were presumably left in the field after hunting. Invertebrates were mostly consumed in summer and autumn. In terms of %B, the most important invertebrates were of family Tettigoniidae (Orthoptera) which represented 31.5 % of this category. The largest amount of insects found in one stomach was 113 g of grasshoppers, from the family Acrididae. Invertebrates' food category includes also specimens of Arachnida and Gastropoda class, Hymenoptera and Coleoptera orders, Scarabaeidae and Asilidae families, and specimens that could be determined to species level—*Gnaptor spinimanus* and *Mantis religiosa*.

During the winter period, the dominance of domestic ungulate carcasses was the most remarkable (Table 1). Carcasses of domestic ungulates and poultry together comprised 78.9 %

Table 2 List of small mammals and their contribution in biomass of this food category

	%B
Rodentia undetermined	1.02
Microtus cf. *agrestis*	1.69
Microtus sp.	53.51
Microtus arvalis	10.42
Arvicola amphibius	1.08
Myodes glareolus	16.90
Apodemus sp.	8.03
Apodemus agrarius	0.20
Gliridae	0.20
Muscardinus avellanarius	0.43
Cricetus cricetus	2.88
Ondatra zibethicus	0.51
Rattus sp.	0.40
Myocastor coypus	2.23
Spalax leucodon	0.01
Talpa europea	0.40
Mus sp.	0.09

of total biomass consumed during winter. Small mammals were represented quite frequently but in smaller amounts (Table 1). The calculated niche breadth for this season (B_A) was 0.2.

The most diverse diet of jackals is recorded during spring (B_A=0.36). The dominance of domestic ungulates is present in spring as well as in winter, although in a lesser extent (Table 1). The contribution of small mammals, plant material and invertebrates in jackal's diet during spring is expectedly higher than during winter, while the contribution of game bird species is reaching maximal values (Table 1).

Small mammals are the most important food type for jackals during summer. They were present quite often and in large quantities. The maximal weight of small mammals in one stomach was 517 g. In a large extent, plant material was also present in diet during summer (Table 1). The heaviest stomach content consisted solely of fruits—myrobalan plums (*Prunus cerasifera*) and mulberries (*Morus nigra*), and weighed 455 g. Comparing all seasons, consumption of domestic ungulates is minimal in summer (Table 1). Contrary to domestic ungulates, invertebrates are most frequently and in the largest quantities eaten during summer (10.7 %O, 3.2 %B). Game animals were a small part of jackal's diet in summer (Table 1), and the relatively high percentage of roe deer (9.8 %B) is due to a single case where a jackal from Surčin ate almost the whole fawn (688 g). The calculated niche breadth for this season (B_A) was 0.27.

Jackals had very diverse diet in autumn (B_A=0.32). Small mammals are dominating in the diet even in a higher percentage than in summer (29.0 %O, 37.0 %B). The highest number of voles in one stomach was at least 24 specimens. The proportion of domestic ungulates is higher than in summer (Table 1). The plant material is still present in high percentage (Table 1). Relatively high frequency of occurrence (7.6 %) of indigestible material suggests that garbage dumps and anthropogenic food resources are important food sources for jackals. Regarding game mammals, no roe deer was found and wild boar and hares were found in low percentage (3.8 %O and 5.4 %B, and 3.1 %O and 3.3 %B, respectively).

Regarding the overlap between seasons, a very high overlap is recorded between summer and autumn (C=0.97) as well as between winter and spring (C=0.94). The G-test showed that there is a statistically significant difference in %B of all food categories between localities (G=26.28, p=0.009; Table 3). No statistically significant difference in %O between localities was found (G=14.5, p=0.41). Furthermore, statistically significant differences are recorded between seasons in %B and %O at the Surčin locality (%B, G=244.51, p<0.01; and %O, G=154.03, p<0.01, respectively), as well as at Veliko Gradište (%B, G=144.5, p<0.01; and %O, G=133.13, p<0.01, respectively) and on the basis of total sample (%B, G=143.28, p<0.01; and %O, G=107.9, p<0.01, respectively).

Table 3 Differences in percentage of biomass consumed (%B) and frequency of occurence (%O) by golden jackals between the two study areas

	Veliko Gradište N=201		Surčin N=93	
Food category	%O	%B	%O	%B
Domestic ungulates	39.37	64.66	23.20	37.18
Poultry	10.06	7.31	5.52	7.09
Small mammals	20.11	10.37	27.62	27.07
Wild boar	1.72	1.38	7.18	6.91
Roe deer	2.01	3.88	2.21	5.92
Hare	2.87	1.78	3.31	3.14
Game birds	2.30	0.85	0.00	0.00
Other birds	2.59	0.21	4.97	0.78
Plant material	8.91	6.57	13.26	2.58
Other carnivores	1.15	0.68	1.10	6.78
Cats and dogs	2.01	1.16	1.66	1.47
Reptiles and amphibians	0.86	0.06	1.10	0.09
Indigestible	3.16	0.17	4.42	0.48
Invertebrates	2.59	0.90	3.87	0.48
Fish	0.29	0.01	0.55	0.03

N represents the number of stomach samples.

Discussion

Results of this study clearly indicate a seasonal variation in jackal's diet in Serbia: winter and spring being more similar as well as summer and autumn. During winter and spring when a high trophic niche overlap is recorded, domestic ungulates are dominating (Table 1) and mostly represented as slaughter leftovers. Although jackals are known as pests in some parts of its range (Brooks et al. 1993; Szabó et al. 2010; Heltai et al. 2013), during the study period, no major complaints on jackals making damage on domestic animals were reported. In this colder part of the year, pig slaughter is common and also as a traditional feast. Low temperatures allow that the leftovers from the livestock stay longer fresh and available to all carrion-eating animals and not only for jackals. This food surely represents an appropriate source for winter survival and a good base for population increase. The broadest dietary niche in this study was during spring coinciding with a period of resource abundance, and the lowest in winter when resources were scarce. During the more favourable part of the year, small mammals and plants were the most frequently found food categories, as previously reported from its Asian (Mukherjee et al. 2004; Jaeger et al. 2007) and European (Lanszki et al. 2010; Lanszki and Heltai 2010; Markov and Lanszki 2012) part of distribution. Summer and autumn diet are overlapping also in great extent. This is the time of the year when plenty of fruit ripens and becomes an important part of

its diet. Moreover, in Veliko Gradište during summer, the plant material is the most important food category regarding both %O and %B. Similar findings are reported in studies conducted in Israel and Eastern Croatia (Borkowski et al. 2011; Bošković et al. 2013). Small mammals are the most important food source for jackals in Surčin during summer. Generally, the category of small mammals was mostly represented with *Microtus* species. Bank voles were presented to a lesser extent (10.3 % of the total biomass of all small mammals; Table 2). This finding is in correlation with results from Hungary (Lanszki and Heltai 2010) where jackals preferred open field living voles and avoided bank voles which are living mostly in forest habitats as well as *Apodemus* spp. and shrews which are generalists upon habitat preference. From previous studies, it is known that small mammals could act as the main food source for jackals (Lanszki et al. 2006; Markov and Lanszki 2012), and their importance for small- and medium-sized carnivore community is often overlooked (Mukherjee et al. 2004). As many other small- and medium-sized carnivores, jackals occasionally consume invertebrates (Carbone et al. 1999). Invertebrates in our study were mostly consisted of grasshoppers and beetles which are known as good source of proteins (Bukkens 1997; Blásquez et al. 2012).

Domestic ungulates were consumed in largest proportions on both localities and thus are representing the staple food of jackals in Serbia (Ćirović et al. 2014). The reason of very high consumption of domestic ungulates—mainly pigs in Veliko Gradište (especially during winter; 74.3 %B)—could be found in a pig farm which is located near our study area. The higher consumption of small mammals in Surčin area could be expected since it is dominantly an agricultural area which could support high abundance of rodent populations. The higher percentage of wild boars in Surčin then in Veliko Gradište is probably due to larger population of wild boars which are kept in a fenced area. The higher consumption of other wild carnivores at Surčin locality is a result of a single finding of a stomach containing more than 1 kg of jackal carcass.

Overall, mammal game species—roe deer, wild boar and hare—were present in a very low percent even during spring and summer when they are having young (Table 1), similar as previously reported in several studies (Lanszki et al. 2006, 2009; Lanszki and Heltai 2010). Farrowing in Serbia occurs between March and May while roe deer give birth during May and June. Wild boar and roe deer were also mostly consumed as viscera or/and skin leftovers which remained in the field after the animal is hunted. Therefore, jackals do not have a major influence on mammal game species populations on these two localities in Serbia contrary to the prejudice of hunters. Moreover, these results should be implemented in the future hunting management of this species.

Results from our research study are indicating that jackals are highly adopted for living in human-modified habitats where they take advantage on human presence and easily accessible food sources as previously reported in India, Israel, Bulgaria and Greece (Macdonald 1979; Brooks et al. 1993; Jaeger et al. 2007; Giannatos et al. 2010; Rotem et al. 2011; Raichev et al. 2013). In this study, two food categories—domestic ungulates and poultry were most commonly represented with remains after slaughter. Unfortunately, regulations and guidelines considering waste disposal are not followed in many areas. Illegal dumps could be found on both localities and generally all over Serbia. On these dumps, plenty of food is available for many opportunistic and carrion-eating animals. At these places, local people dispose livestock offal after slaughter for household needs. These results are in accordance with studies conducted in neighbouring Bulgaria and Greece as well as in Israel (Dolev et al. 2009; Lanszki et al. 2010; Borkowski et al. 2011; Raichev et al. 2013).

From the literature, it is known that jackals in natural ecosystems of Africa are facultative cooperate hunters when wanting to improve the likelihood of success of catching a larger prey (Moehlman 1987). In this study as well as in other studies carried out in human-dominated landscapes (Giannatos et al. 2010; Lanszki and Heltai 2010; Markov and Lanszki 2012; Raichev et al. 2013), wild ungulates are represented in a very small percentage as a prey contrary to abundant small mammals and easily accessible food like domestic livestock carcasses and fruit. This implies that jackals most probably have solitary hunting strategy (when hunting small mammals) instead of hunting in large groups.

Although several papers are published concerning trophic niche overlap with red foxes (Lanszki and Heltai 2002; Lanszki et al. 2006), more research on jackal feeding ecology is needed especially in terms of trophic niche overlap with other competitors such as grey wolves and roaming dogs (Aiyadurai and Jhala 2006). Further research is needed for an assessment of the human impact on the availability of food sources provided to jackals. Apart from garbage dumps, these anthropogenic food sources include viscera remains of game species after hunting, carcasses of stray cats and dogs shot in hunting grounds as pests or as road kills, and fruits and maize that are cultivated for human consumption.

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