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Diet composition of the golden jackal, *Canis aureus* in an agricultural environment

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Abstract. Diet composition of the golden jackal (*Canis aureus*, L.) in Bulgaria, where the largest jackal population in Europe occurs, has been studied by scat analysis in a typical and newly occupied agricultural environment. The study was carried out during late summer and early autumn, a period when small mammal density is high. The food of the jackal typically consisted of small-sized and wild-living prey species. Rodents have been found to represent the primary food of the jackal (biomass estimation: 59.3 %, mainly *Microtus* spp.), and the European brown hare (*Lepus europaeus*, 20.1 %) and plants (19.7 %, mainly fruits) are secondary foods. Other prey, such as birds (mainly passerines), reptiles and invertebrates had been consumed in a low biomass ratio. No remains of wild ungulate and domestic animals have been detected in the studied scats.

Key words: feeding habits, scat analysis, rodent, prey, Bulgaria

Introduction

The golden jackal (*Canis aureus*, L.) is a food opportunistic canid, showing high flexibility in hunting strategies according to the actual food availability (Lamprecht 1978, Macdonald 1983, Demeter & Spassov 1993). Its diet patterns vary across a wide distribution range in the southern part of the northern hemisphere in Eurasia and Africa (Demeter & Spassov 1993, Yom-Tov et al. 1995, Kryštufek et al. 1997, Jhala & Moehlman 2008), where its food spectrum ranges from plants, arthropods, and reptiles to birds, lagomorphs, rodents and poultry; it preys upon the young domestic or wild ungulates, but is also a scavenger.

The results of game counts carried out during the last decades in Bulgaria (110842 km^2) showed a clear trend of increasing numbers of jackal all over the country. In 2003 the jackal population in Bulgaria was 26730 animals, in 2007 its numbers was 30000 individuals (AEFA 2003, 2007) and in 2010 it reached 36000 individuals (Russev 2010). The increase in the jackal population in the last decades was confirmed by data from the number of animals which have been shot in Bulgaria: in 1983 it was 5538 animals, in 1999 it was 7422 animals (AEFA 1983, 1999) and in 2010 it was 26570 animals (ABHFU 2010). The high numbers found in the country (Markov 2011) and the large numbers of shot animals demonstrate that at the present the largest jackal population in Europe inhabits the territory of Bulgaria. Recently, new lowland agricultural habitats (as in our study area) and also mountainous habitats are being occupied by jackals in high numbers (Russev 2010). However, no quantitative information was available on the seasonal food spectrum and feeding habits of the species living on recently occupied areas of Bulgaria. High predation upon ungulates (especially fawns) and livestock was presumed as it has been reported from semi-mountainous regions of the country (Stenin et al. 1983, Genov & Vassilev 1991).

In order to understand better the ecology of the golden jackal in Bulgaria, it is necessary to study the feeding habits in different seasons and habitats. The present study is a beginning as it was carried out on a typical agricultural area during the season when small mammal density was high (food was unlimited), and the expected results can be compared with other European studies. In the study period (at the end of

summer and beginning of autumn) young jackals have already joined the family group and so jackals may hunt not only alone or in pairs, but also in larger groups (Demeter & Spassov 1993). Accordingly, we expected a possible diverse hunting strategy in diet composition.

Due to a lack of information about jackal feeding habits in Bulgaria the aim of the present study was to evaluate the diet composition of the jackal in a lowland agricultural environment during a period of high density of small mammals.

Material and Methods

The study area is situated in the central part of Pazardzhik-Plovdiv region within the Western Upper Thracian Valley (central Bulgaria, 42° N, 24° E, 168 m above sea level), the largest (ca. 6000 km^2) lowland area in Bulgaria (Donchev & Karakaschev 2004). After the jackals spread into lowland agricultural habitats their numbers in the Pazardzhik-Plovdiv agricultural region greatly increased, reaching 365 animals in Pazardzhik region and 1312 animals in Plovdiv region in 2010, and it is believed that today the Western Upper Thracian Valley has 1677 jackals (estimated numbers, AEFA 2010).

The typical agricultural character and recent occupancy by jackals were the main reason for choosing this area for the food study. The cultivation of thermophilic crops, e.g. wheat, corn, peach, grape, cotton, tobacco, rice, is favoured by the warm climate and agriculture is well developed (Georgieva & Vladev 2007). Natural vegetation cover in the region has a very limited area. Forests (ca. 10 %) are represented by small isolated areas dominated by oak (*Quercus* spp.), and hornbeam (*Carpinus* spp.) (Bondev 1991). A small part of the study area (ca. 12 %) is covered with meadows. Hydrophilic communities consisting mainly of willow and poplar are typical for the terraces of the main river of the area, namely Maritsa, and its tributaries (Bondev 1991). The climate is dry and continental (500-600 mm rainfall per year, Georgieva & Vladev 2007). Due to the intensive agricultural activity in the Pazardzhik-Plovdiv region the density of several small rodents, e.g. *Microtus* (*M. arvalis*, *M. levis*) and *Apodemus* species (*A. sylvaticus*, *A. flavicollis*) is high (8-10 colonies/ha, Markov & Dekov 2008, Markov et al. 2009). Besides rodents and insectivores, medium-sized mammals occur in the area, e.g. European brown hare (*Lepus europaeus*), red fox (*Vulpes vulpes*), wildcat (*Felis silvestris*). Roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) are present in small numbers, but are not of hunting interest (Markov 1962, IBHSF 2010). Ornithofauna of the region is typical for agricultural areas, represented by partridge (*Perdix perdix*) around the cultivated areas and quail (*Coturnix coturnix*) during migration. Common pheasant (*Phasianus colchicus*) is bred in farms (Spasov 2008, IBHSF 2010). During migration, duck and goose species occur around wetlands in large numbers (G. Markov's personal observations). The meadows are regularly grazed by herds of domestic animals (cows, goats, and sheep) during the day but they are driven into stables for the night.

The diet of the jackal was studied by scat analysis. The finding and inclusion of a relatively low number of jackal scat samples in the analysis might be predetermined through preliminarily outlined target of the study – examination of the food spectrum of the species from a new, not typical for its dissemination homogenous agricultural landscape in the short time period in which in the region was characterized by high densities of small mammals. Fresh jackal scat samples (n = 16, each corresponding to one scat) were collected sometimes in piles, within a circle of 1-1.5 m diameter (Macdonald 1979) in August and September 2008 on a standard route in a 10-km-long transect. These transects were distant (2 km) from settlements in order to minimize the presence of domestic dog and its scat samples. Golden jackal scat samples were distinguished from domestic dog and red fox faeces on the basis of odour, size and shape characteristics (Macdonald 1980, Lanszki et al. 2006), and in addition, predator hairs collected from scats were morphologically identified (e.g. Teerink 1991, and our own reference collection).

Processing the jackal scat was based on a standard procedure. Diet composition was expressed in two ways: relative frequency of occurrence (O) and percentage of biomass consumed (B) following Jędrzejewska & Jędrzejewski (1998). To estimate the fresh mass of food ingested, scats were soaked in water, then washed through a sieve (0.5 mm mesh) and dried. The presence of earthworms was examined before leaching the scat. All dry food remains were separated and identified under the microscope with the aid of keys from Teerink (1991), März (1972), Brown et al. (1993), and our own vertebrate, invertebrate and plant reference collections. Then, all dry remains were weighed and the mass data were multiplied by an appropriate conversion factor summarized by Jędrzejewska & Jędrzejewski (1998) for red fox (small rodents 23, hare 50, birds 35, reptiles 18, insects 5 and plant material 14). Trophic niche breadth was calculated in accordance with Levins and standardised

(Krebs 1989). The following food taxa were used for these calculations: small mammals, European brown hare, birds, reptiles, invertebrates and plant matter.

Results

Regardless of which method was used to express diet composition, the main food source of the jackal in the study area was small rodents (O: 42.9 %, B: 59.3 %, Table 1). The most important were *Microtus* voles but *Apodemus* species were also eaten in high biomass proportion. According to a biomass calculation, closer to the quantitative composition of the consumed food, the second most important food for the jackal consisted of two equally important taxa, the European brown hare (B: 20.1 %) and plants (B: 19.7 %, mainly fruits). The jackal consumed birds, reptiles and invertebrates in low biomass proportions (Table 1). Remains of wild and domestic ungulates were not found in the jackal scats.

According to the environmental association of animal food items (Table 1), jackals definitely did not feed on human-related animals (living on and around settlements), and only preyed upon wild-living (O: 48.6 %, B: 65.4 %) and habitat generalist species (O: 51.4 %, B: 34.6 %). The prey species were mainly small in weight (< 50 g; O: 71.4 %, B: 72.0 %, Table 1).

Standardized trophic niche breadth values were relatively high (Table 1), and 12 different animal and eight plant taxa were found in the scats. Undigested, inorganic material, such as nylon foil (four cases) and salami skin (1) occasionally occurred in the samples probably from waste.

Table 1. *Diet composition of golden jackals (*Canis aureus*) in Bulgaria. Prey weight (P.w.) categories: 1 = below 15 g; 2 = 15-50 g; 3 = 51-300 g; 4 = above 300 g). Prey habitat association (P.h.) categories: w = wild-living; g = habitat generalist (which may live both in the wild as well as near to settlements). N = number of items in each taxa, % O = percentage relative frequency of occurrence, % B = percentage biomass consumed, + = occurring in proportions lower than 0.05 %, B_A = standardized trophic niche breadth value, n = 16 scats, 56 food items.*

Food items	P.w.	P.h.	N	% O	% B
Common vole *Microtus arvalis*, sensu lato	2	w	11	19.6	28.7
Field vole *Microtus agrestis*	2	w	1	1.8	3.2
Field mouse *Apodemus* spp.	2	g	10	17.9	25.4
Dormouse Gliridae spp.	2	w	1	1.8	0.4
Mus spp.	1	g	1	1.8	1.6
European brown hare *Lepus europaeus*	4	w	3	5.4	20.1
Perching birds Passeriformes spp.	2	g	2	3.6	0.2
Undetermined medium-sized birds	4	g	1	1.8	0.2
Snake Colubridae spp.	3	w	1	1.8	0.1
Locust Acridoidea spp.	1	g	2	3.6	+
Mantid *Mantis* spp.	1	g	1	1.8	+
Stag beetle *Lucanus cervus*	1	g	1	1.8	0.4
Plum *Prunus* spp.			3	5.4	10.5
Pear *Pyrus* spp.			1	1.8	4.8
Other fruit			5	8.9	0.7
Sunflower seed *Helianthus annus*			1	1.8	2.9
Grass			7	12.5	0.8
Other plant material			4	7.1	0.1
B_A				0.40	0.26

Discussion

Feeding patterns of the jackal in the study period on this recently occupied lowland agricultural area of Bulgaria differed mainly in the missing consumption of wild- and domestic ungulates from those reported for semi-mountainous regions of the country (Stenin et al. 1983, Genov & Vassilev 1991). Similar to our results, in a year-round study in neighbouring Greece, no consumption of wild ungulates was reported (Giannatos et al. 2010), and very low consumption ratios of cervids has been detected in other studies from the autumn period (Lanszki et al. 2009, 2010). In the established feeding patterns European brown hare was also found in a Croatian study (Radović & Kovačić 2010) in higher amounts than in other European studies (Lanszki et al. 2006, 2009, Giannatos et al. 2010). The considerable presence of fruit and vegetables in the jackals' diet (e.g. Radović & Kovačić 2010) confirmed that plants might play a seasonally important role in the feeding of jackals. The low content of birds in the scats was in accordance with the evidence of low bird consumption outside the nesting season found most studies (reviewed by Demeter & Spassov 1993). The high content of small rodents found in jackal scats in this study confirmed their significance as a main prey type for jackals during that period when food is unlimited. High consumption of small mammals was found in numerous studies in Asia (Demeter & Spassov 1993, Mukherjee et al. 2004, Jaeger et al. 2007), in Africa (Lamprecht 1978) and in a European agricultural area (Lanszki et al. 2006, 2010), and this food type is clearly preferred by the jackal (Lanszki & Heltai 2010).

The food spectrum revealed in this study during the time of an increase in the density of jackals and an expansion in range across Bulgaria, showed that the

high density of small mammals was likely to affect food availability and survival of this species in a lowland landscape with a sharp increase of agricultural environment.

The results might be influenced by different factors: (i) the study period was outside the birth season of ungulates, but in a time of high numbers of small mammals, (ii) samples were collected (56 food items were found in scats) during a short period, (iii) transects covered were relatively small and in a homogenous agricultural landscape. It is not sure whether the results found for the jackal diet are general for habitats in agricultural areas and whether similar results would be obtained in further studies of its feeding spectrum in different agro-ecosystems or in semi mountain landscapes.

In conclusion, the primary food of the jackal consisted of small mammals (mainly rodents), and secondary foods were the European brown hare and plant material (mainly fruits) in the lowland agricultural region of Bulgaria, during late summer (and early autumn) when small mammal density was high. In contrast with earlier observations (Stenin et al. 1983, Genov & Vassilev 1991), carried out mainly in mountainous and semi-mountainous regions of the country, no predation upon wild ungulates and domestic animals was found.

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