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DIET OF ADULT AND JUVENILE GOLDEN JACKALS (*Canis aureus*) DURING CUBS` DEPENDENCY STAGE

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Abstract: Golden jackal populations in the Balkans are increasing and spreading its range. Nowadays vagrant specimens are reaching the northern parts of Europe. As one of the prerequisites for actual population increase is a solid food base, we examined the feeding habits of adult and juvenile jackals in Serbia in the period of cub dependency stage. During a seven year period (2007-2013), stomach contents of 49 adults and 28 cubs from period July-October were analyzed. Juvenile jackals had less diverse diet than the adults, represented with eight food categories. During this part of the year, jackals of both age categories were mostly consuming small mammals. Moreover, small mammals were the main prey category in the diet of juveniles (49.82 % of biomass consumed and 32.08 % of frequency of occurrence). No game species were recorded in the diet of juvenile jackals. During their first summer and autumn, jackal cubs already manifest the opportunistic feeding behavior. They take advantage of easily accessible food sources such as fruit and slaughter leftovers from domestic ungulates and poultry.

Key words: Canis aureus, cub feeding, diet, golden jackal, opportunism, stomach content analysis

Introduction

Golden jackal (*Canis aureus*) is a medium sized canid species with a wide distribution. It is a fairly common species throughout its range due to its tolerance of dry habitats and their omnivorous diet (Sillero-Zubiri et al., 2004). In Europe, it occurs mainly in its southeastern and central parts (Sillero-Zubiri et al., 2004). Balkan Peninsula is considered its core area of distribution in Europe, from which this species is currently spreading towards Central, Western and even Northern Europe (Kryštufek et al., 1997; Arnold et al., 2012; Šálek et al., 2014; Trouwborst et al., 2015).

Although known from the beginning of Holocen, jackals in Europe had a very dynamic distribution range in the past. Main reasons of former population number decline in Europe, apart from habitat loss, were non-selective techniques which were used after WWII for poisoning overabundant wolf population (Spassov, 1989). These activities influenced not only the wolves but also all other carrion eating animals, including jackals. During the last two decades of XX century jackal populations in southeastern Europe begun to increase in number and started spreading their range toward north and west, mainly along big river streams (Danube, Tisa, Drava, Sava) (Szabó et al., 2006; Tóth et al., 2009).

Jackals in Serbia, unlike many European countries (Hungary, Republic of Macedonia, Slovenia) have never disappeared (Arnold et al., 2012). They maintained on very low densities until the beginning of 1980`s when their population started to increase in number and widen their range (Milenković, 1983; 1987; Stevanović & Vasić, 1995; Ćirović et al., 2014). Nowadays the jackal`s range in Serbia covers about two thirds of total territory (Ćirović et al., 2008; 2014). One of the main reasons for its fast population size increase in a short period of time, which is described as an expansion, is opportunistic way of feeding. Moreover, omnivorous diet and the presence of 'helpers' (full siblings to the young pups which provision and guard the pups) influence the higher rate of pup survival (Rubenstein & Wrangam, 1986).

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Jackals mate in February-March (Heptner et al., 1988) and give birth in a den after 60-63 days (Sheldon, 1992). The average litter size in neighbouring Bulgaria ranges from 4.9±1.4 pups on the north to 6.2±1.6 pups on the south (Vassilev & Genov, 2002). There is no data for Europe about the pup survival in initial 14 weeks which are the most critical for survival (Moehlman, 1987). Lactation usually lasts for 8–10 weeks (Sillero-Zubiri et al., 2004) and at 14 weeks the pups are starting to forage with adults (Moehlman, 1987).
Furthermore, with fast population growth and range expansion conflicts with humans are inevitable. They are based mostly on a common belief and prejudice of hunters and wildlife managers that jackals cause big damage on game species, predominantly on roe deer population (Mihelič & Krofel, 2012; Penezić & Ćirović, 2015).
The aims of this study are therefore to determine what are the main food categories for jackals during cub rearing season; whether there are differences in the diet of adults and juveniles and which game species are important in their diet during summer and autumn when they need to gain fat reserves for winter, the most unfavourable part of the year.

Material and methods

This research is based on stomach content analyses. Diet of the adult and juvenile golden jackals was studied during seven consecutive years in period July – October, 2007-2013. In this period pups eat solid food either provided by adults or foraged with adults. During the study period, 85 legally hunted jackals (55 adult jackals and 30 cubs) were obtained in cooperation with local hunting organizations from four areas: Surčin, Pančevo, Smederevo and Veliko Gradište. Eight samples (six adults and two pups stomachs) were excluded from further analyses since stomachs were empty. The analyses were performed for remaining 77 specimens.
Necropsy of the hunted animals is performed in the field and the stomachs were frozen at -20 ˚C. The stomachs were processed in detail afterward at the laboratory of the Faculty of Biology, University of Belgrade, Serbia. After the stomachs were thawed, a longitudinal section with scissors was performed and content was removed and measured with accuracy of 1g. The content was then examined macroscopically and the remains were categorized into 12 categories: European brown hare (Lepus europaeus), rodents, wild boar (Sus scrofa), birds, domestic ungulates (pig, sheep), poultry (chicken and turkey), mustelids, lizards, fish, plant material (seeds, fruits, grass, etc.), invertebrates, and indigestible material (e.g. plastics and aluminium foil). Each pile of different food category was weighed separately and rinsed with water using 0.5 mm aperture sieve. Teeth, jaws and hair were separated from undigested bodies of small mammals to facilitate identification. Teeth and bone fragments were cleaned of attached tissue, bleached with 10% solution of hydrogen peroxide, rinsed, air-dried at room temperature, and stored until final identification. Hairs were degreased with alcohol and air dried. Microscopic slides were prepared as described in the atlas and identification key (Teerink, 1991). The identification of prey species was performed to the lowest recognizable taxon using relevant keys (Mirić 1970; Pucek, 1981; Teerink, 1991; De Marinis and Agnelli 1993; Kryštufek & Janžekovič, 1999) and our own reference collections of feathers and hairs.
The diet composition was expressed 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 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 mass (g) of a food category divided by the total mass of all food categories and then multiplied by 100.
Differences between adults and juveniles in the amount of food consumed and number of food categories per stomach were tested by using Student's t-test. In order to detect the differences in %O and %B between these two age classes G-test (with Williams correction) was used. Statistical analyses were conducted using Statistica 5.1 (Statsoft, Tulsa, OK, USA).

Results

During the research period, an average stomach content (± SD) of an adult jackal weighted 132.06 ± 97.22 g and consisted of two (2.2) food categories. Pup`s stomach content on average (± SD) weighted 100.28 ± 103.73 g and consisted also of two (1.9) food categories. There was no statistically significant difference between adults and juveniles regarding to amount (g) of biomass consumed ($t=1.34$, $p=0.18$) nor to the number of food categories found per stomach ($t=1.31$, $p=0.19$). The maximum number of food categories found per stomach of an adult jackal was five and three among pups. In terms of percentage of

biomass consumed (%B), according to G test, there are statistically significant differences between these two age categories (G=19.87, p=0.01) unlike the frequency of occurrence of food categories, where no statistically significant differences have been recorded (G= 13.24, p=0.28).
Wide food spectrum of adult jackals was recorded, with 12 food categories while in pups eight of them were recorded. Relative frequency of occurrence per food item (%O) and percentage of biomass consumed (%B) for adults and juveniles are presented in Table 1.

Table 1. Diet composition of adult and juvenile golden jackals during the period of cub dependency stage in Serbia.

	adults	juveniles	adults	juveniles
Food category	%O	%O	%B	%B
Birds	3.67	5.66	2.61	0.21
Domestic ungulates	20.18	22.64	22.67	22.79
Fish	0.92	-	0.03	-
Hare	3.67	-	4.11	-
Indigestible	3.67	3.77	0.17	0.25
Invertebrates	6.42	1.89	2.91	0.04
Lizards	0.92	-	0.05	-
Mustelids	0.92	1.89	0.68	1.07
Plant material	24.77	28.30	23.55	22.47
Poultry	2.75	3.77	4.71	3.35
Small mammals	29.36	32.08	34.40	49.82
Wild boar	2.75	-	4.11	-

%O – frequency of occurrence per food item, %B - percentage of biomass consumed

Small mammals were the most important type of prey for both adults (29.36 %O and 34.40 %B) and juveniles (32.08 %O and 49.82 %B). Within the category of small mammals, *Apodemus sp*., *A. agrarius*, *Cricetus cricetus*, *Microtus cf. agrestis M. arvalis* and *Microtus sp*. (as the lowest recognizable taxa) were in common for adults and juveniles. Moreover, in adults *Mus sp*., *Muscardinus avellanarius*, *Myocastor coypus*, *Myodes glareolus* and *Spalax leucodon* were detected while in juveniles *Microtus subterraneus* was found. The maximal number of small mammals (voles) found in a cub`s stomach was 21.
Furthermore, in this part of the year plant material (consisted mostly of fruits) is important for jackals of all ages. In the diet of pups as well as in adults, mulberries (*Morus nigra*), plums (*Prunus sp*.), grape (*Vitis sp*.), sunflower (*Helianthus annuus*), maize (*Zea mays*) and grass (*Poa sp*.) were registered. Diet of adults was more diverse including cherries (*Prunus avium*), myrobalan plums (*Prunus cerasifera*), sloe (*Prunus spinosa*) and pears (*Pyrus sp*.).

High percentage of domestic ungulate carcasses was found in the diet of both age categories - 20.18 %O and 22.67 %B in adults and 22.64 %O and 22.79 %B in pups. Leftovers after slaughter of pigs dominated this food category except of a single case of a lamb carcass. Most commonly skin and intestines were found. Moreover, during this research period there was no complaining on jackals making damages on livestock.
All other food categories were represented in markedly smaller percentage (Table 1). From game species, roe deer although present in all these localities was not found in the jackal`s diet. Wild boar and European hare were found only in the diet of adult jackals. Wild boar was not found as a prey but only in terms of skin and leftovers after hunting. From game bird species, only common pheasant was recorded once in an adult jackal from Veliko Gradište.
Invertebrates were found more often in adults (6.42 %O) then in juveniles (1.89 %O). All the findings in adults were of specimens from order Orthoptera.

Discussion

Rodents are the most important food category in Serbia for jackals in summer and autumn as previously reported (Penezić & Ćirović, 2015). In this part of the year due to abundant food sources, rodent densities are high and therefore expected to be represented to significant extent in jackal's diet. Moreover, rodents are very important part of the diet of jackals in India where 56% to 75% of analyzed scats contained rodent remains (Mukherjee et al., 2004; Jaeger et al., 2007). Furthermore, this finding is in accordance with the results from Europe. In Bulgaria during late summer and early autumn rodents comprised 59.3% of the biomass consumed (Markov & Lanszki, 2012). In the same study, results are indicating the dominance of *Microtus* spp. which is in accordance to our study. Similarly, in Hungary the dominant type of food are rodents with dominance of vole species (Lanszki et al., 2006).

In India, jackals are known as opportunistic feeders that consume large amount of fallen fruits. They are recognized as one of the most important frugivorous mammals of which the dispersal of many plant species depends on (David et al., 2015). Plant remains are found also very frequently (51%) in Pakistan, although in very small percentage in terms of biomass consumed (Nadeem et al., 2012). The same study shows that the frequency of occurrence in summer and autumn ranges from 25 to 41.9%. Plant material is also recorded frequently in Croatia where 44.9% of analyzed stomachs contained this food category (Bošković et al., 2013). Moreover, during summer, plant material is after small mammals the second most important food type for jackals in Serbia with 23.8 %O (Penezić & Ćirović, 2015).

Domestic ungulates occurred also in a high percentage during this research period (22.64 %O in juveniles). It is known that this food category is predominant in the diet of jackals in Serbia during winter (Ćirović et al., 2014) even in a much greater extent (56.1 %O, 77.7 %B).

Birds and their eggs were found in the diet of jackal pups in Serbia in much lesser extent (Table 1) than in Greece (35.7 %B) where this food category was dominant (Lanszki et al., 2009). In the same study in Greece (which is the only study on juvenile jackal diet so far), small mammals which are dominant food category for jackal pups in Serbia is been recorded with only 5.8 %B and 2.6 %O. In Greece, domestic ungulates were recorded in higher percentage (31.7 %B) than in this study (22.8 %B). Pups in Greece consume goat and sheep leftovers while in Serbia only pigs were recorded in pup's diet. Furthermore, jackal pups in Greece consume very often plant material (33.8 %O) like in Serbia, but unlike insects which were found more often in Greece (27.5 %O).

Moreover, in Greece wild ungulates, hares, fish and reptiles were present in the diet of juveniles (Lanszki et al., 2009) unlike in this study where these categories were present only in the diet of adult jackals. Differences in juvenile jackal's diet from Greece and Serbia are probably due to different habitat and time of the collection of material. Moreover, the study in Greece was based on scat analyses while in Serbia on stomach content.

In conclusion, even though statistical significant differences in consumed biomass between adult and juvenile jackals from Serbia were registered, most important food for both age categories were small mammals, plant materials and domestic ungulates. During the analyzed period, adult jackals had more diverse diet comparing to juveniles. Our results confirm opportunistic feeding strategies for both age categories which previously confirmed in literature (Lanszki et al., 2006, 2009; Markov & Lanszki, 2012; Bošković et al., 2013; Ćirović et al., 2014; Penezić & Ćirović, 2015). Further research based on stomach contents analyses could be complemented and facilitated with application of DNA barcoding (Santos et al., 2015).

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