

GOLDEN JACKAL (*CANIS AUREUS*) IN BULGARIA. CURRENT STATUS, DISTRIBUTION, DEMOGRAPHY AND DIET.

Stoyanov, S.¹

Summary: Golden jackals are becoming a species of great economic impact in Europe due to their increasing numbers and their influence on game losses. However, their diet, demography, population size and density are poorly known in Bulgaria. Understanding jackals' demographic rates is crucial for management and conservation. Using gathered data and age distribution of 140 collected skulls it was estimated that the minimal golden jackal population size in spring 2006 was between 29 169 and 38 836 animals (95% CI, Mean=34 058, SD=2 492). About 2-3 pups (average 2.6) per breeding pair survive to the autumn, when more intensive jackals chase starts. A map of golden jackal distribution and density in Bulgaria was made using the data of shooting records. The golden jackal range in Bulgaria covers almost 80 000 km², which is about 72 % of the country total land area. The density in spring, before breeding, in different municipalities varies between 1 and 15 (mean 4) jackals/10 km². Preliminary data on golden jackal diet were discussed.

Keywords: golden jackal, population size, density, demography, diet

Introduction

The golden jackal (*Canis aureus* L., 1758) is one of the most widespread canid species, occurring in southeastern Europe, northern and eastern Africa, and in large parts of Asia eastward to Thailand [10]. The northern border of the European resident population is along the Danube in Romania and former Yugoslavia [21]. In Europe the jackal occurs in North Italy, Slovakia, Austria, Hungary, South Poland, Slovenia, Croatia, Bosnia and Herzegovina, Albania, Montenegro, Macedonia, Serbia, Greece, Romania, its highest densities being on the Balkan Peninsula. Apart from Greece, where the jackals are on the decline and listed as vulnerable in the national Red List [13], the species has expanded its European distribution range, most notably in Bulgaria, where there was a 33-fold increase in the area inhabited by jackals between the 1960s and the 1980s and which now supports the largest jackal population in Europe [12, 21]. Vagrant animals have repeatedly been recorded from northeastern Italy, Slovenia, Austria, Slovakia, and Macedonia [5, 21].

In Bulgaria, the golden jackal is one of the most numerous predators. It is the second in numbers from all of the canids, after the red fox. Its population has been increasing in the last few decades, and it has become the most popular predator for hunting. Its skin is valuable, and it is no less interesting to chase jackals than wolves and foxes. At the same time the jackal is often blamed for the game decrease. It is considered the main factor causing game losses. Golden jackals are becoming a species of great economic impact in Europe due to their increasing numbers and their influence on game losses. However, their demography and population size are poorly known in Bulgaria. Understanding jackals' demographic rates, assessment of population size and their diet is crucial for management and conservation.

The present study aims to review the golden jackal distribution, population size and density in Bulgaria. Gathered data and age distribution of collected skulls will allow estimation of golden jackal demographic parameters such as survival and fecundity rates. Preliminary data and references on golden jackal diet, along with estimated density and distribution reveal golden jackal's significance and its impact on the game species in Bulgaria.

Material and Methods

Estimation of the golden jackal rate of increase was made based on the annual gathered data taken from the national database of Executive Forestry Agency. For mapping of jackal distribution were used data only for the hunting areas of the Union of Hunters and Anglers in Bulgaria (UHAB), but in most cases they were the same or close to the total gathered in Bulgaria. In the state hunting areas, for example, 661 jackals were shot in 2006. Total harvest for 2006/07 hunting season was 18,564, and the harvest in areas of UHAB was 17,903. The number of harvested jackals reported could be considered correct because of awards being paid for every shot animal.

Age structure of golden jackal population was reconstructed using the age distribution of shot jackals from different ages. Jackal skulls from 91 shot animals were collected between 1998 and 2006. The skulls were collected from two main regions covering different parts of golden jackals' distribution area in Bulgaria. One of the regions was South Eastern Bulgaria – Yambol, Bourgas, Radnevo, Sredec, and the other was Central part of Northern Bulgaria – near Veliko Tarnovo. There were also jackals collected in other parts of the country. Golden jackal has appeared in high mountains above 1000 m a.s.l. and Stara planina Mountain couldn't be considered a physical barrier. The collected samples in different study areas came from the same countrywide population. Rajchev [34] collected and determined the age of 49 jackals from Central Balkan and Sredna Gora Mountain, near Stara Zagora.

¹ Corresponding author: Stoyan Stoyanov, Assistant Professor, Wildlife Management Dept., Faculty of Forestry, University of Forestry, Sofia, Bulgaria, e-mail: stoyans@abv.bg, phone: +359888441606, +35928687391.

These animals were added to our sample, because they were from the same population and collected in the same period.

Specimens were aged based on upper incisive teeth wear [22], and for 27 of them also by counting the annual rings of canine teeth cement [20]. The accuracy of the first method is 1 year until the age of 3 years [22]. Only 6 animals were classified as 4 years old and 3 – as 5+ years old, because all of the teeth were worn out. The error could be more than 1 year for these animals, but their number is too small to influence the results. The second method is much more accurate, but time consuming and expensive, requiring special equipment. It determines the exact age if there is no error in counting annual rings. Rajchev compared both methods and excluding 3 cases they gave the same results [34]. Harris *et al.* suggested using the wearing of teeth for age determination of badgers. The method was as reliable as counting the annual rings of canine teeth cement [16].

Constructing the life table, based on the age distribution of shot jackals, was made following the methods described by Caughley [8] for vertical life table and Udevitz & Ballachey [46] for depositional life table. A more detailed description of the development of last method is presented by Skalski *et al.* [39]. Golden jackal population size and density were estimated using survival rates from constructed life table and harvest data. The methods are explained in detail in [43]. For estimating variance and 95 % confidence intervals of the survival rates and the total population size was used nonparametric bootstrap. Calculations and graphics were made using R [33] and package *boot* [7, 9]. Eigen analysis on Leslie matrix was made with R using code provided by Stevens [42].

Map of golden jackal distribution in Bulgaria was created using GRASS [15] and QGIS [32]. Again, data of shooting records were used to represent distribution and density of jackals on a map.

The golden jackal diet was studied by analysis of stomach content. Total 95 stomachs were analyzed between 1998 and 2007, collected from the end of July until the beginning of March. Stomach content was weighed, filtered and macroscopically sorted out into categories. The determination of different food components was made using guides [31, 45] and comparative material. Hairs were examined microscopically. All feathers were determined by Joahim Menzel. The most applied method of presenting results when analyzing carnivores' diet is by frequency of occurrence from all stomachs or from all stomach components. Although the best approximation of the true diet can be obtained by using a biomass calculation model [19], for preliminary results in this paper the frequency of occurrence method was used.

Results and discussion

Golden jackal was widespread in Bulgaria in prehistoric times [4]. Due to its rapid decrease in the middle of the XX century the species was strictly protected. At this time, the golden jackal survived only in South-Eastern Bulgaria, and its basic locations were in Strandzha Mountain [10, 30, 40]. After receiving protection status in 1962, the golden jackal has started gradually to expand its distribution in Bulgaria. At the beginning of the 1970s its number had to be regulated, because of the damages the jackals caused to livestock. Since 1977 awards have been paid for shot jackals in spite of its protection status [30]. Following legislative protection in 1962, the golden jackal initially re-colonized its former territories in Bulgaria [40]. It was excluded from the list of protected species in 1984. Nowadays the golden jackal is one of the most numerous predators in Bulgaria. Different authors estimated the golden jackal population size in Bulgaria between 5000 and 10000 [3, 10, 30, 35, 40, 41]. According to the official data of the State Forestry Agency, golden jackals in Bulgaria in 2007 were about 30000. It is hard to say if these data are correct. The jackals were counted every year during annual game counting scheme, using inappropriate census methods for carnivores.

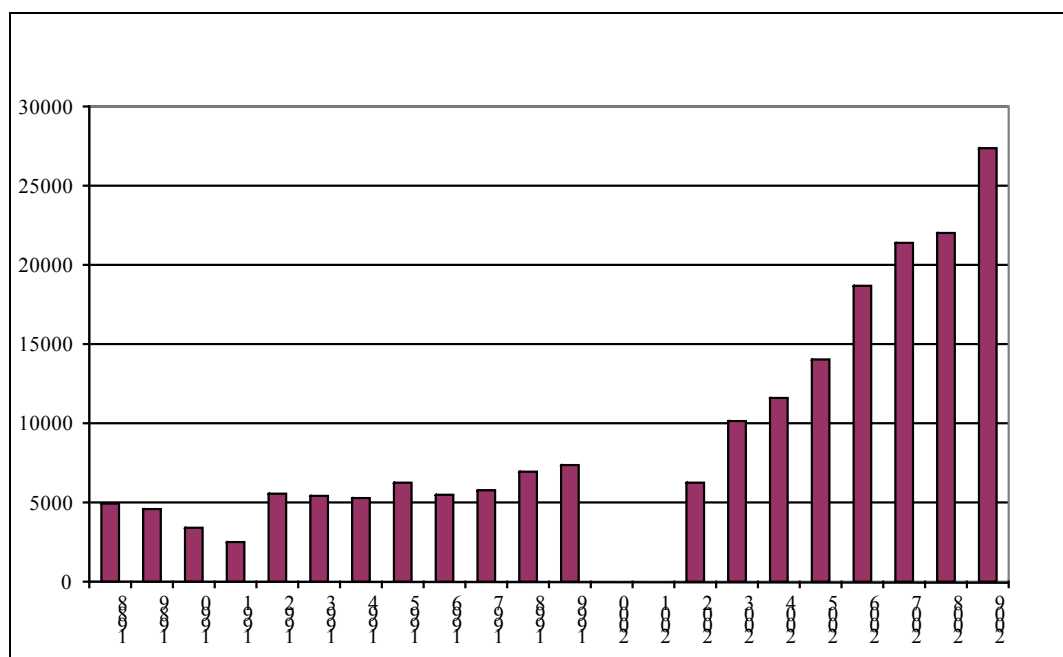


Fig. 1. Golden jackal shot in Bulgaria in the last two decades.

The only accurate data are shooting records (Fig. 1). After 1999 golden jackal population size was gradually increasing. Unfortunately, the data for 2000-2001 were missing, but it is clear that since 2002 the number of shot jackals had been rapidly increasing. It may be a consequence of more regular payment of awards for the shot jackals, but it is more likely to be due to higher density of jackal population.

From harvest data we estimated the finite rate of increase of golden jackal population size $\lambda=1.133$. Received results along with age distribution of collected skulls, corrected for growing population, allowed us to construct a life table for hypothetical golden jackal population in Bulgaria (Table 1). The data showed that about 10 % of jackals from one cohort could reach the age of 5 years and more, and jackals above 3 years comprise only 6 % of the population.

Table 1. Life table for hypothetical golden jackal population in Bulgaria.

Age x , years	Number of animals alive at age x	l_x	$SD(l_x)$	95 % Confidence intervals for l_x
0	57	1.000	-	-
1	45	0.789	0.101	0.597-0.983
2	31	0.544	0.088	0.368-0.719
3	15	0.263	0.065	0.140-0.386
4	10	0.175	0.054	0.070-0.281
5+	6	0.105	0.042	0.035-0.193

Along with estimation of the life table parameters, we estimated the ratio "Population size/Harvest" (Fig. 2). It was supposed that the main reason for golden jackal mortality was hunting. Knowing survival rates and harvest, the estimation of population size was possible [43]. Given that in 2006/2007 hunting season the harvest was 18 734 golden jackals, the minimal population size of golden jackal in spring 2006 should be between 29 169 and 38 836 animals (95% CI, Mean=34 058, SD=2 492). Received estimation of golden jackal's population size was above the population size according to the official data. The Executive Forestry Agency gave the following data from the national annual spring counting – 28 523 jackals for 2006, and 32 819 jackals for 2007 respectively. Lack of coincidence between our estimation and official data is acceptable. As it was mentioned the jackals were counted only when ungulates were counted, using inappropriate census methods for carnivores.

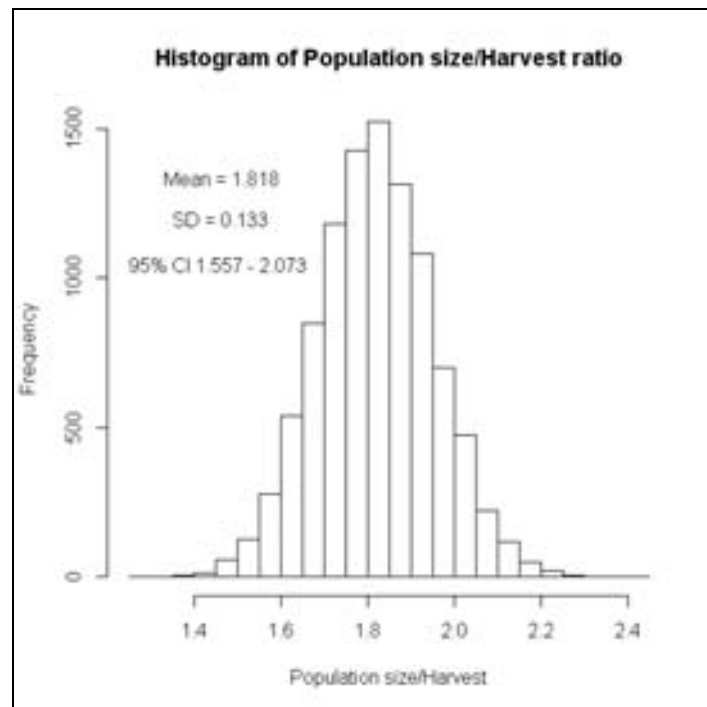


Fig. 2. Estimate of the variance and 95 % confidence intervals for the Population size/Harvest ratio applying bootstrap with 10000 replicates.

The received estimation was lowered, because we accepted that the total mortality was due to hunting, but this is not the case. There were naturally occurring deaths, and it cannot be said that the golden jackal death rate was entirely due to chase. The road traffic for example caused 3.6 % of the jackals' mortality in our sample. There are many other factors causing natural mortality, but probably the main factor is hunting.

One possible source of bias in the estimated age structure, survival rates and population size is that the sample of collected skulls could not be representative for the population. The young animals are shot more often than adults, and thus the proportion of animals younger than 1 year in the harvest can be higher than that in the population. If harvest sample was biased, then n_0/n should differ from n_1/n_{1+} (where n_x is the number of animals from age class x). More juveniles and sub adults would be included in the sample than those from other age groups. Smirnov [6] noticed such bias in the proportion of young animals in samples of shot wolves. In the analyzed sample n_0/n was almost identical to n_1/n_{1+} , 0.41 and 0.48 respective, compared with proportion test ($\chi^2=0.901$, $df=1$, $p=0.3425$). Even the first ratio (n_0/n) was smaller. This means that hunting methods did not give any preference to younger animals. Most jackals were shot in late summer, autumn and winter. Probably the chance of shooting young or adult jackals at that time is equal. Samples were collected applying variety of hunting methods, but mainly three methods were widely used – driving, with or without dogs, blind or stand hunting, baiting. In very rare occasions, other methods were used, for example calling. Only 5 animals were found dead on roads. The variety of hunting methods applied supposed lack of selection, because every method could be selective for different age groups.

The fecundity rate F also was estimated (Mean=1.317, SD=0.135, 95 % CI=1.088-1.621). Assuming equal sex ratio, we could infer that 2-3 pups (average 2.6) per breeding pair survive to the autumn, when jackals that are more intensive chase starts. Applying Eigen analysis on the Leslie matrix, using initial age distribution for our sample, we estimated the future stable age distribution (Fig. 3). Detailed explanation of the methods applied was given in [43].

Looking forward it is clear that population size is growing with the constant rate of increase. We estimated λ from harvest data collected between 1997 and 2006. If we tried to verify our model and estimated harvest for 2009 it should be $18\ 734 \lambda^3$, which is 27 269. The data showed that 28 196 jackals were shot in the 2009/2010 hunting season. The harvest increase is thought to be due to population growth, and not due to more intensive chase and regular payment of awards for shot jackal in the last decade. It seems impossible that jackal's harvest could increase three times for ten years only due to intensive chase in certain areas, and not due to population growth in Bulgaria.

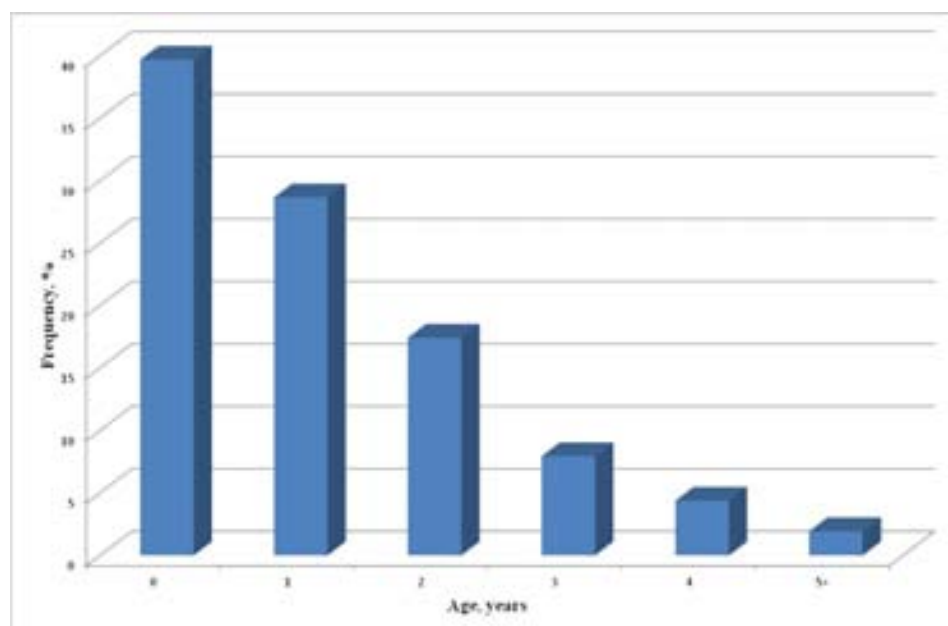


Fig. 3. Stable age distribution of the golden jackal population in Bulgaria.

A good pattern of golden jackal distribution and density in Bulgaria was obtained from the data of shooting records. The average shooting records for 2004-2009 in every local hunting association were presented on a map of Bulgaria, using the data of the National Hunting Association - Union of Hunters and Anglers in Bulgaria (Fig. 4). Although the data represents not only the golden jackal's density but also the chase intensity and activity of hunters, it becomes clear in which areas golden jackals have the highest density. The habitats golden jackal in Bulgaria prefers are river valleys, watersides, reed beds, bushes and small forests in lowlands. It rarely climbs up above 800-900 m but it has been spotted in several areas above 1000 m. The golden jackal range in Bulgaria covers almost 80 000 km², which is about 72 % of the country total land area. Golden jackal reached that distribution area already at 1985 [12, 10, 21], but its population size has dramatically increased in the last two decades.

The average shooting records for 2004-2009 in every local hunting association, used for mapping golden jackal distribution, were applied also for estimating golden jackal density in Bulgaria. The density was estimated dividing population size to the respective area. The population size was assessed following already received ratio "Population size/Harvest" (Fig. 2). The density in spring, before breeding, in different municipalities varies between 1 and 15 (mean 4) jackals/10 km². The highest density of 15 jackals/10 km² actually was the mean density for the respective municipality. Surely, there were areas with higher mean density. The results for the golden jackal's density in Bulgaria are comparable with other studies within golden jackal's range, although the data are very scarce (Table 2). The most of the highest densities shown were observed in areas with aggregations of jackals while the presented density for Bulgaria was the average density for every municipality. It should be mentioned that our data referred to spring density, before breeding. Density in autumn, including pups that survived until that time, was almost 1.67 times higher as was made clear by the present study.

Table 2. Golden jackal's densities estimated in different areas within its range.

Country, Region	Density estimate, jackals/10 km ²	Reference
Bulgaria	1-15 (mean 4)	Present study
Greece	30	Giannatos <i>et al.</i> , 2005
Romania, Dobrudzha	0.8	Angelescu, 2004
Hungary	13.6	Szabo <i>et al.</i> , 2009
Azerbaijan	7.3	Gitayatov, 1965 (in Demeter & Spassov, 1993)
Israel, Golan Heights	20-40 (mean 25)	Yom-Tov <i>et al.</i> , 1995
India, Velavadar National Park	10-20	Jhala & Moehlman, 2004
Tanzania, Serengeti National Park	40	Moehlman, 1983, 1986, 1989

Note: Densities in Greece, Israel, India and Tanzania was reported originally by the authors as number of jackals per 1 km². The data in the Table were converted for clarity.

The jackal's expansion in Bulgaria at the beginning of the 1980s was explained by partial protection since 1962, increasing of small game species and by reduction and local extermination of the larger wolf [30]. The key factors for the jackal's expansion nowadays are different. The golden jackal is a highly adaptable species [18]. It can migrate over long distances in search for food [1]. It has high reproductive capacity. One female gives birth to 3-12

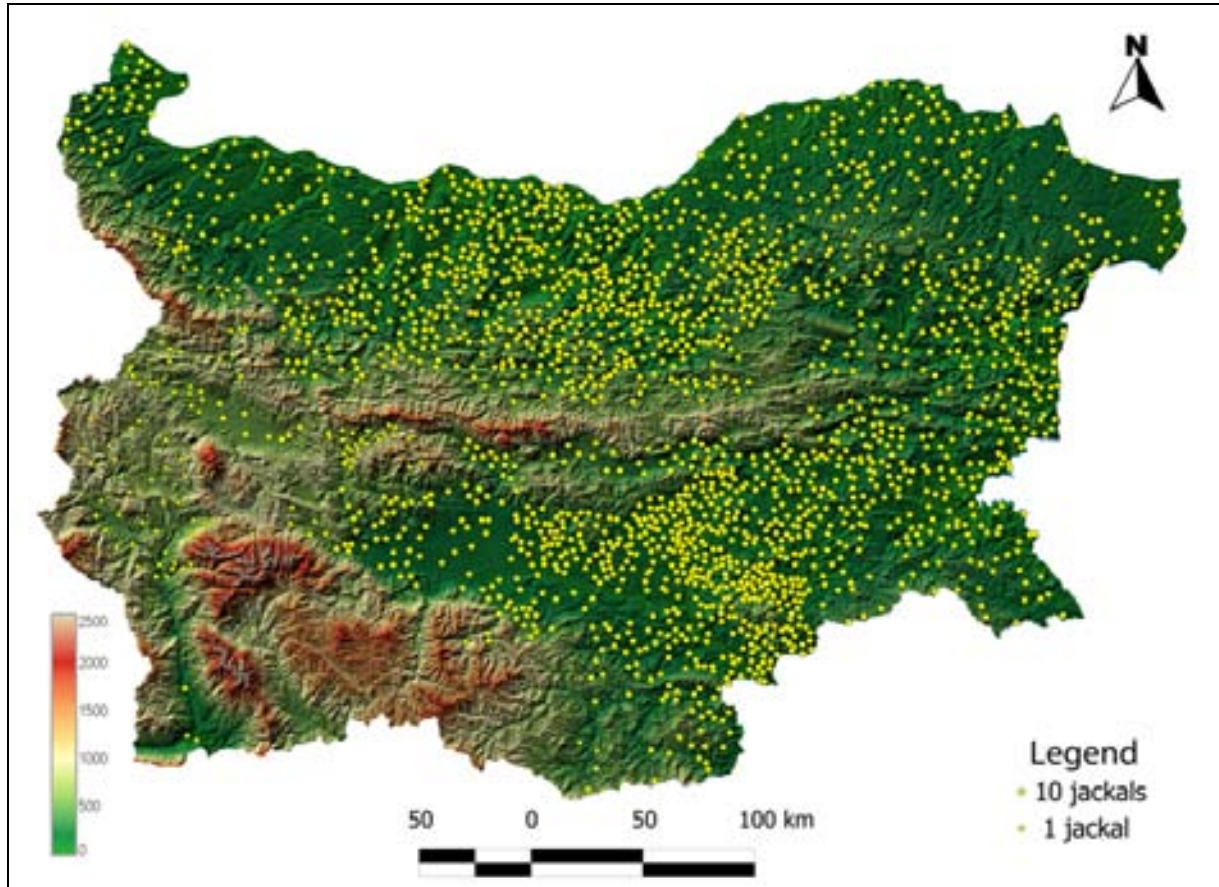


Fig. 4. Golden jackal distribution and density in Bulgaria in 2004-2009 based on harvest data (average number of jackals shot between 2004 and 2009 is shown). The circles on a map are randomly distributed and do not show exactly the points where jackals were shot but it represents jackal's density in different municipalities.

pups (average 6) in South Bulgaria, and 3-8 pups (average 5) in North Bulgaria [47]. We received fecundity rate of 2-3 jackals that survived in late summer per female, which means that 40-50 % of newborns survive to the age of 3-4 months. The initial 14 weeks are crucial to survival of pups and all observed mortality occurred within this period. In Tanzania the average number of pups that survive to the age of 14 weeks per litter (from a typical litter of six pups at birth) was 2.3 (SD = ± 1.5 , $n = 23$) [26]. In our sample almost 40 % ($n=140$) of animals were juveniles. It is interesting to mention that in one study in Kenya, concerning the ecology of three sympatric jackal species, juveniles comprised 45 % ($n=29$) of *Canis mesomelas*, and 47 % ($n=17$) of *Canis aureus* that had been captured [11]. The juveniles they captured were nearly adult size with adult dentition, suggesting they were 6-11 months old, which means the jackals had the same reproductive rate compared to that in our study.

Another reason for the jackal expansion could be the availability and accessibility of food resources. Golden jackals are omnivorous and opportunistic foragers, and their diet varies according to season and habitat. It feeds mainly on small mammals (voles and mice), birds, fruits, seeds, acorns and crop, fish, insects, reptiles, crustations, carrion and garbage [4, 24, 25, 27, 28, 34, 36, 37, 49]. Livestock in some areas is the most important part of the diet, although it was presumably scavenged [14, 48]. The opportunistic nature of golden jackals is illustrated by their catholic diet and their ability to flourish where human rubbish is abundant [23, 48]. In parts of the range garbage dumps could be vital for the jackals' survival [17, 29].

Our preliminary data (72 of 95 stomachs (12 empty) collected from jackals shot all over the country were analyzed) showed that the golden jackal diet consisted mainly of mammals (occurrence of 87.5%, of which 41,7% was rodents), birds (36,1%), vegetable matter (30,6%, mainly fruits, seeds, acorns and crop), fish (12,5%), insects (9,7%) reptiles (1,4%) and crustations (2,8%) (Table 3). The voles (*Microtus sp.*) were the most frequent prey of all

rodents. In most cases common vole (*Microtus arvalis*) was found. In few cases in jackal's diet mice (*Sylvaemus sp.*) and other small mammals like hedgehog (*Erinaceus concolor*) were found. Only 3 species of game birds were found in jackal's diet: mallard, quail and snipe. They were probably wounded or dead birds because they were found during the hunting season. Most other birds of jackal's diet were herons and songbirds occurring in reed beds and other. Many domestic mammals and birds found in the diet were carrion found on garbage dumps near villages. This was the case with domestic pigs, cats and dogs, and fowl found in the stomachs. Sometimes the stomachs consisted mainly of garbage, sausage and potato peelings, tomato and pepper seeds, fowl feathers, skin and bones. Wild boar was the main jackal's prey among big game, but it was uncertain if jackals had caught it alive or found carcasses or remnants (mainly skin) left by hunters. Vegetable matter was found in almost 60% of stomachs, but in half of them, it consisted of grasses and leaves accidentally taken in with the food by jackal. Only plant matter taken as main food, fruits, grapes, crop, acorn and others, were considered significant. Mainly plants were found in only 2 stomachs, one of them collected at the end of July contained only sunflower seeds. In other cases, vegetable matter was combined with insects, small mammals and birds.

Table 3. Golden jackal diet in Bulgaria.

Food	Occurrence		Food	Occurrence	
	n	%		n	%
I. Animals	70	97,2	C. Reptiles	1	1,4
A. Mammals	63	87,5	Balkan Wall Lizard (<i>Podarcis taurica</i>)	1	1,4
Rodents (Mice and Voles)	30	41,7	D. Fish (Mainly fam. Cyprinidae)	9	12,5
Hare (<i>Lepus capensis</i>)	1	1,4	E. Crustaceans (<i>Potamon potamius</i>)	2	2,8
Hedgehog (<i>Erinaceus concolor</i>)	1	1,4	F. Insecta	7	9,7
Golden Jackal (<i>Canis aureus</i>)	3	4,2	Beetles (Coleoptera)	2	2,8
Domestic Dog (<i>Canis familiaris</i>)	7	9,7	Grasshoppers (Orthoptera)	4	5,6
Cat (<i>Felis sp.</i>)	1	1,4	II. Plants	43	59,7
Roe Deer (<i>Capreolus capreolus</i>)	1	1,4	Grasses (Poaceae)	26	36,1
Wild Boar (<i>Sus scrofa</i>)	7	9,7	Sunflower (<i>Helianthus annuus</i>)	3	4,2
Domestic Pig	10	13,9	Maize (<i>Zea mays</i>)	1	1,4
Domestic Sheep	1	1,4	Wheat (<i>Triticum spp.</i>)	1	1,4
B. Birds	26	36,1	Grape (<i>Vitis vinifera</i>)	7	9,7
Squacco Heron (<i>Ardeola ralloides</i>)	1	1,4	Apple (<i>Malus sylvestris</i>)	2	2,8
Little Egret (<i>Egretta garzetta</i>)	2	2,8	Pear (<i>Pyrus communis</i>)	1	1,4
Greylag Goose (<i>Anser anser</i>)	1	1,4	Plum (<i>Prunus domestica</i>)	2	2,8
Mallard (<i>Anas platyrhynchos</i>)	2	2,8	Hawthorn (<i>Crataegus monogyna</i>)	1	1,4
Quail (<i>Coturnix coturnix</i>)	1	1,4	European Cornel (<i>Cornus mas</i>)	1	1,4
Fowl (<i>Gallus gallus domestica</i>)	1	1,4	Melon (<i>Cucumis melo</i>)	1	1,4
Crake (<i>Porzana sp.</i>)	1	1,4	Watermelon (<i>Citrullus lanatus</i>)	1	1,4
Snipe (<i>Gallinago gallinago</i>)	2	2,8	Pepper (<i>Capsicum annum</i>)	2	2,8
Little Owl (<i>Athene noctua</i>)	1	1,4	Tomato (<i>Solanum lycopersicum</i>)	3	4,2
Warbler (<i>Locustella sp.</i>)	1	1,4	Walnut (<i>Juglans regia</i>)	1	1,4
Great Tit (<i>Parus major</i>)	1	1,4	Leaves and acorns of oaks (<i>Quercus sp.</i>)	1	1,4
Bearded Reedling (<i>Panurus biarmicus</i>)	1	1,4	Leaves of Ash, Oak, Hornbeam and Birch	6	8,3

Game species are very rare in jackal's diet. Wild boars are consumed mainly as carcasses. The increase of golden jackals in the last decade has coincided with the dramatic decrease of the major big and small game species. It is clear that the game is not the main jackal's prey. It is another question if the golden jackal is able to cause damage to game species when they are abundant. It should be mentioned that all these data were collected in late summer, autumn and winter. To be more precise stomachs should be collected in spring, during the breeding season and hatching of many birds, and in the months when most mammals give birth to their offspring. Thus it would be possible to conclude if the golden jackal is "guilty" or not for the population decline of game species. The present studies in Bulgaria are insufficient to answer this question.

Along with the golden jackal, the red fox is a common predator in Bulgaria. Although the jackal is bigger in size than a fox, their dietary habits are identical, and they are therefore in direct competition with one another. One study in Israel showed that foxes generally ignored jackal scents or tracks in their territories, though they would avoid close physical proximity with jackals themselves. Studies have shown that in areas where jackals became very abundant, the population size of foxes decreased significantly, apparently because of competitive exclusion [38]. In Bulgaria, the number of jackals and foxes are not correlated, but the increase of these two species coincided, probably because of the similarity of their diets. Their competition should be mainly for rodents and carrion [34].

In Bulgaria, jackals have been shown to vacate areas inhabited by the larger grey wolf. In areas where wolves are present jackals do not occur. It could be seen if the distribution of the grey wolf and golden jackal were compared on a map. Wolves are often actively intolerant of jackals in their established territories and have been known to approach jackal-calling stations at a quick trotting pace, presumably to chase off the competitors [13]. There were however occasions when jackals scavenged on wolf kills without provoking any aggressive behavior of the larger canids [18].

Conclusions

The golden jackal is highly adaptable species. It has the ability to survive under various conditions and to live in various habitats. The jackals can easily expand their range and colonize new habitats. Hunters evidently could not suppress this expansion, although such a large number of jackals were shot every year.

The jackal distribution nowadays is not unusual. The species has occupied again the range that it inhabited in the past. The present status of golden jackal in Bulgaria does not require any special measures. It is not clear if it causes significant damages to game or livestock. Jackals should be hunted with the methods and means that have been used so far. It is illogical to consider total persecution and extermination of jackals. In spite of their wide distribution nowadays it is not impossible for jackals to become extinct in the greater part of their range again in near future. Such fluctuations in jackal population have happened in the past [4, 10, 21, 30, 40]. Golden jackal has its place in the nature and has to be preserved for the future.

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