

## Current distribution of golden jackal (*Canis aureus L.*) in Romania and its effects on competitors and prey species

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**Abstract:** In the period of 2006 – 2017 based on stock assessments data performed by hunting organizations, the Romanian golden jackal (*Canis aureus L.*) populations had increased their distribution area from 13 to 37 counties out of the total 41. In the same time the stock assessment data shows a 6.7-fold exponential growth from 1,871 specimens to 12,206. However, many European previous study results denote an uneven distribution pattern and regional core areas inside distribution range. These features are characteristic for Romanian distribution range as well, but only in terms of differing densities. At the level of year 2017, the current distribution area of golden jackal in Romania seems to become continuous and covers approximately 90,000 km<sup>2</sup> that represents about 41% of the country total area.

We studied the diet of jackals and those of red foxes (*Vulpes vulpes L.*) using stomach content analysis, and body weight of foxes from areas where they live sympatric with golden jackals and from golden jackal-free habitats. Effects of the jackal's diet on prey species and issues of the competition between mesopredators are discussed.

Our diet analysis results show a wide trophic niche breadth, lower small mammal consumption and higher plant matter consumption in comparison with other study results. Anthropogenic food did not occur in substantial proportions, neither small game (hare and pheasant) species. We found that the most important big game species in golden jackal's diet is the wild boar. Protected prey species were not found in golden jackal's diet. It seems that the golden jackal is a typical food generalist omnivorous species, without any constraints in terms of abundance limiting food source. Nevertheless, we have found high nutritional niche overlap between golden jackal and sympatric red fox. Comparative analyses of body weights of red foxes living sympatric with golden jackal and of those without contact with this species revealed that the golden jackal does not affect the population densities of red foxes, but the mean body weight of sympatric juvenile red foxes is smaller than in golden jackal free areas.

**Keywords:** golden jackal, spatial distribution, Romania, red fox, mesopredator competition

### 1. Introduction

Since the late 1960's when the Danube was considered as the northern boundary of the golden jackal's (*Canis*

*aureus L.*) spreading area (Cotta and Bodea 1969), and in Romania were registered only random occurrences, nowadays this carnivore species is common in many parts of the country.

However, the knowledge about the jackal is limited both in local game management and nature protection fields as well.

In cases when a new predator species arrives into an ecosystem, biodiversity losses are suspected. In assessing the impact of golden jackal, the question must be considered through dispersal patterns, predation aspects and competition (Stratford 2015).

Describing dispersal patterns of golden jackal in different European countries, there were used many similar terms as e.g. intermittent (Banea et al. 2012), discontinuous (Szabó et al. 2007), scattered or sporadic (Kryštufek et al. 1997; Lapini et al. 2011), fragmented (Comazzi et al. 2016) and patchily (Lanszki et al. 2007).

There is a very important aspect which must be considered when distribution area estimations are performed. This is the clear distinction between areas colonized by resident breeding populations, and territories where only some vagrant specimens were observed (Kryštufek et al. 1997).

Despite of controversies of game management data, these are the most appropriate to range expansion studies. In special the yearly approved hunting quotas can provide useful information.

Approval process of hunting quotas in Romania starts from the hunting organizations. Based on stock assessments performed in spring period, the hunting organizations requests quotas for a number of individuals they want to extract. The authorities, (Romanian Ministry of Environment, Water, and Forests –

MEWF) as a rule, approve the requested golden jackal quotas except the cases when the quotas approved for the previous hunting season were not extracted. Such situations occur mostly within recent distribution area. In those areas, hunting quota requests are based on sightings of some vagrant individuals, whose extraction is very difficult. In other words, if at a game management unit there is hunting quota for golden jackal in two consecutive years that means that the quota of previous hunting season – at least partially – was extracted. Therefore, these hunting grounds could be considered as colonized and part of the recent distribution area.

Once known the distribution area, population growth trends and range expansion rate, the suspected effects of golden jackal on indigenous fauna can be analyzed. The predation effect of the jackal on indigenous fauna can be assessed through diet studies.

In natural ecosystems diet of golden jackal is dominated by rodents, while other wild living prey species and plants are secondary foods (Demeter and Spassov 1993; Lanszki and Heltai 2002; Lanszki et al. 2006; Lanszki et al. 2010; Markov and Lanszki 2012; Farkas et al. 2015; Penezic and Čirović 2015). In terms of potential ecologic and economic losses, impact on protected and game species must to be studied.

At the same time, it is generally accepted that wolves dominate jackals, and jackals dominate foxes (Kryštufek et al. 1997; Giannatos et al. 2005; Lanszki et al. 2006; Scheinin et al. 2006; Stoyanov 2012; Farkas et al. 2017). The golden jackal could affect

the red fox populations directly, through intraguild predation or indirectly through feeding competition. However, competition can occur if a given number of organisms exploits the same scarce, vital resources (Elmhagen and Rushton 2007). One powerful evidence of premises for feeding competition between golden jackal and red fox can be a high dietary niche overlap.

In this study: (1) we made an update of golden jackal's current distribution area in Romania, and (2) presented preliminary data for assessing their effects on prey species and the most important competitor, the red fox, through feeding habits.

## 2. Materials and methods

Romania covers an area of 238,391 km<sup>2</sup> (National Institute of Statistics [http://statistici.insse.ro/shop/TEMPO\\_AGR101A](http://statistici.insse.ro/shop/TEMPO_AGR101A) downloaded at 16.02.2017). According to the last update (M.D. no. 2298 from 29.11.2016) of Decree no. 193/2002 of Ministry of Agriculture, Food, and Forests (MAFF), the hunting area comprises 220,455.33 km<sup>2</sup> or 92.47% of the country total area. The total hunting area is delimited in 2,152 game management units commonly named as hunting grounds. The management of wildlife and its habitats, within game management units is accomplished by 552 hunting organizations.

Based on data provided by MEWF, we calculated the tendencies of stock assessments as well as that of

approved and executed hunting quotas for the period of 2006 - 2017.

From the same data and the same period, we extracted the numbers of counties and hunting organizations with jackal presence, and studied the evolution of those.

For trend calculations, we fitted the most common models on basic data. Correlation coefficients were calculated between the raw data and fitted models. As characteristic for tendencies we accepted the models with stronger values of correlation coefficients because of p-significance values below five decimals.

Estimation of the golden jackal rate of increase was performed based on 2006 – 2016 period's official stock assessment data gathered from MEWF.

As stock assessments data could be controversial using inappropriate census methods and periods for carnivores (Stoyanov 2012), we performed the golden jackal distribution area estimations based on official hunting quotas. Game management units with approved hunting quotas in two consecutive years could be considered as areas with resident breeding populations.

Diet of the golden jackals and red foxes was studied during three consecutive years between 2013 and 2015, using stomach content analysis. The locations of the studies were 10 hunting grounds in the southern part of Romania. The grounds, having a total surface of 88,185 ha, are typical lowland habitats (1-100 m a.s.l.). The mean multiannual temperature is 11.5°C and the average annual precipitation is 518 mm. 78.6% of the

total surface is occupied by arable lands, 12.1% by pastures, 7.9% by forests, wetlands and water courses cover 0.86%, while the rest of 0.54% are unproductive areas. The forests are distributed in patches and are dominated by oak species (*Quercus* spp.), ash species (*Fraxinus* spp.) and white poplar (*Populus alba*).

The stomach contents were examined macroscopically, and the remains were categorized into 16 categories (table 1). The diet composition was expressed as relative frequency of occurrence per food item. 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 (Penezic and Ćirović 2015).

Trophic niche overlap between golden jackal and red fox was calculated by means of the Renkonen index:  $P_{jk} = [\sum n (\text{minimum } p_{ij}, p_{ik})] \times 100$ , where  $P_{jk}$  is the percent overlap between species  $j$  and species  $k$ ,  $p_{ij}$  and  $p_{ik}$  are the proportions of resource  $i$  represented within the total resources used by species  $j$  and species  $k$ , and  $n$  is the total number of resource taxa (Krebs 1989).

Trophic niche breadth was calculated for both species in accordance with Levins (Krebs 1989):  $B = 1/\sum p_i^2$ , where  $p_i$  is the relative frequency of occurrence of the  $i$ -th taxon. Standardized across  $n = 16$  food taxa:  $BA = (B-1)/(n-1)$ , rating from 0 to 1.

Thematic mapping was performed using QGIS version 2.16.3, while statistical analyses were carried out

using STATISTICA version 13 (Dell 2016) and Microsoft Excel. Statistical significance for all tests was inferred at  $\alpha = 0.05$ .

### 3. Results

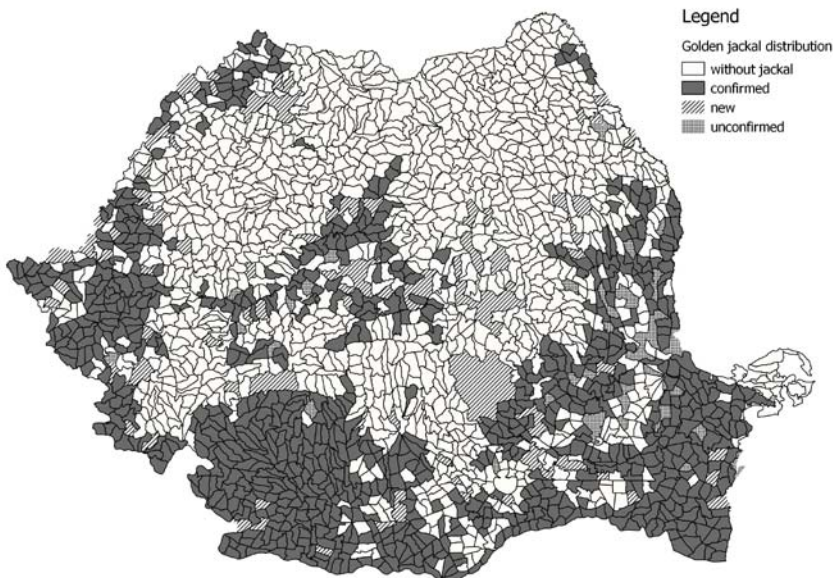
In period of 2006 – 2017 based on stock assessments data performed by hunting organizations, the Romanian golden jackal populations had increased the distribution area from 13 to 37 counties out of the total 41. In the same time the stock assessment data shows a 6.7-fold exponential growth from 1,871 specimens to 12,206.

We accepted as characteristic for tendencies of golden jackal population growth the exponential model because of stronger correlations ( $r_{\text{exponential}} = 0.9903$ ,  $p < 0.00001$ ;  $r_{\text{linear}} = 0.9738$ ,  $p < 0.00001$ ).

From stock assessment data we estimated the finite rate of increase (FRI) of golden jackal population size, which result is  $\lambda=1.194$ . Accuracy of this estimation will be tested in the spring of 2018, when the stock assessments will be executed. Our estimated FRI of  $\lambda=1.194$  should result in stock assessment data around 14,570 specimens in 2018.

In the 2017/2018 hunting season there are approved hunting quotas on 963 game management units, with a total area of 102.703 km<sup>2</sup>. One season before, the number of game management units with golden jackal quota was 855 and their area summed 89.869 km<sup>2</sup>. Number of game management units with approved hunting quotas in two consecutive years (2016 and 2017) is 808, and their area covers 85,204 km<sup>2</sup> (Figure 1).

**Confirmed, unconfirmed and new presence of Golden Jackal in Romania, in spring of 2017**



**Figure 1 - Different types of golden jackal distribution in Romania**

Stomach content analyses, without testing the seasonal patterns, showed a brief image of mesocarnivore’s yearly diets (table 1).

Small rodent consumption was important but not as dominant as we could expect (21.29% on jackals and 27.11% on foxes). Different bird species appeared more frequently in fox’s diet (27.70%) than in those of jackals (6.93%). Wild game species such as wild boar, brown hare, roe deer and pheasant were present generally in small amounts (0.29-5.54%) in stomachs, except the jackal’s wild boar consumption which was 12.38%. Domestic animals and other anthropogenic food items occurred only occasionally both in jackal and fox diet (0.87-3.47%). Seeds, fruits, and other plants were very important for jackals (37.62%) as well as for foxes (19.53%).

Food item	Jackal n=119	Red fox n=238
1. Shrews (Soricidae)	0.00%	0.29%
2. Voles	15.84%	21.28%
3. Mice	4.46%	4.37%
4. Other rodents	0.99%	1.17%
5. Brown hare	1.49%	0.29%
6. Cervids (Roe deer)	0.50%	0.29%
7. Wild boar	12.38%	2.62%
8. Carnivore mammals	0.99%	0.29%
9. Domestic animals	1.98%	0.87%
10. Birds	6.93%	27.70%
Pheasant	1.98%	5.54%
Other birds	4.95%	22.16%
11. Reptiles, amphibians	3.47%	2.33%
12. Fish	0.50%	0.00%
13. Invertebrates	9.41%	17.20%
14. Seeds and fruits	24.26%	13.12%
15. Other plants	13.37%	6.41%
16. Anthropogenic food items	3.47%	1.75%

**Table 1 – Diet composition of golden jackal and red fox**

Comparative analyses of diet of golden jackals and red foxes, revealed that jackals have wider trophic niche



breadth ( $B = 7.35$ ;  $BA = 0.45$ ) than the foxes ( $B = 5.66$ ;  $BA = 0.33$ ). The trophic niche overlap between these carnivore species is 65.51%.

#### 4. Discussion

The uneven distribution pattern and regional core areas inside distribution range found in previous European studies (Kryštufek et al. 1997; Lanszki et al. 2007; Szabó et al. 2007; Lapini et al. 2011; Banea et al. 2012; Comazzi et al. 2016) are characteristic for Romanian distribution range as well, but only in terms of differing densities. At the level of year 2017, the current distribution area of golden jackal in Romania seems to become continuous and covers approximately 102,703 km<sup>2</sup> that represents about 43% of the country total area.

However, it must be clearly distinguished the resident breeding populations and vagrants (Kryštufek et al. 1997). The realistic current colonized distribution area – in the context of ongoing expansion – could be between the confirmed 85,000 km<sup>2</sup> and estimated 102,000 km<sup>2</sup>, somewhere near 90,000 km<sup>2</sup>.

Golden jackal's prey preferences could not be tested with our methodology. At annual scale, the seasonal predation effects may remain hidden. The small rodent consumption can be considered as an ecosystem service, but we have found these food items in smaller amounts than in previous study results (Lanszki and Heltai 2002; Lanszki et al. 2006; Markov and Lanszki 2012). At the same time, the game species consumption – if derive from

predation and not from scavenging – could cause substantial economic losses, mainly if it is concentrated upon the recruitment in the spring period. Our dietary study results suggest that the golden jackal in Romanian habitats acts as a typical food generalist omnivorous species, without any constraints in terms of abundance limiting food source.

The nutritional niche overlap of 65.51% between the golden jackal and red fox can be considered as very high. Similar results of dietary niche overlap were found previously in Hungary (60-77%) in winter – spring period (Lanszki and Heltai 2002) and an average of 73% in a four years research period (Lanszki et al. 2006). In Romania 72.22% of nutritional niche overlap was found at annual scale between sympatric golden jackal and red fox (Farkas et al. 2015). However, despite of the high trophic niche overlap, in Romania at the actual population densities only indirect evidences of feeding competition were found between the sympatric golden jackal and red fox (Farkas et al. 2017).

#### 5. Conclusion

As result of the present study we made an updated map of golden jackal's current distribution area in Romania. We considered this important, because the previously used distribution maps (including the IUCN's global distribution map) nowadays are outdated.

The current management practices with hunting quotas and without hunting seasons, are hard to be evaluated. But at least, the hunting bag

data makes possible the indirect monitoring of the expansion range. At the same time, the specimens extracted by regulated hunting could provide samples to various studies on biometry, age structure, reproduction, or diet.

Our dietary study results present only preliminary data on feeding habits of the golden jackal. Based on these, we did not find evidences of serious damages caused to livestock or game species, nor threats on biodiversity. Further dietary studies should investigate the seasonal patterns and prey preferences in various types of habitats, as well as the effects on the most plausible competitor species, the red fox.

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