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The rise of a carnivore, the evolution of the presence of the golden jackal in Slovakia

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Abstract. The golden jackal (*Canis aureus* Linnaeus, 1758) is one of the most widespread canid species. Nowadays, it is a permanent species from the Slovak fauna. In recent years, their number has grown and the dispersion range has increased in our country. The first evidence of this species was recorded in 1947 and after 1989 the records of jackal presence increased steadily, most originating from the South of Slovakia. The presence of the golden jackal was quite evident from 2009 until 2016 as results demonstrate a great significance in terms of numbers during this period. The collected data is very consistent between culling data (strong evidence) and opportunistic observations (presumable evidence). Patterns of first migrating individuals presented in this work, confirmed previsions of the direction of the dispersion of this species to North from the Balkans region. Presumably, much of the migration occurred from Hungary as most of the first official records of the golden jackal in Slovakia are from areas close to the Hungarian border. This work aims to review and evaluate available official data and literature of *Canis aureus* in Slovakia. It also intends to summarise the status of this species and correlate it with historical data.

Key words: *Canis aureus*, mesocarnivore, expansion, management, occurrence

Introduction

The golden jackal (*Canis aureus* Linnaeus, 1758) is a middle-sized carnivore from the genus *Canis* (Jhala & Moehlmann 2008, Krofel et al. 2017) and considered amongst wolf-like canids as a monophyletic species (Wayne et al. 1997, Bardeleben et al. 2005). Compared to other canid species, the golden jackal has one of the largest wide-range distributions amongst Europe and Asia (Moehlmann 1983, Sillero-Zubiri et al. 2004, Arnold et al. 2012, Rutkowski 2015). Due to their high adaptability in different landscapes, opportunistic predator behaviour and omnivorous diet, the golden jackal is expanding its territory range through Europe (Heltai et al. 2013, Krofel et al. 2017). Throughout its actual geographical range, this mesocarnivore occupies multiple habitats, from extreme deserts to dense forests (Kryštufek & Tvrtković 1990, Kryštufek et al. 1997, Giannatos 2004, Lapini et al. 2009, Arnold et al. 2012, Trouwborst et al. 2015, Krofel et al. 2017). The highest probability of observing this species is generally at crepuscular hours, but their activity pattern in places where they live near humans is mostly nocturnal (Ginsberg & Macdonald 1990,

Patil & Jhala 2008). It is a social animal, found to live in monogamous pairs or in organized family groups, but can easily live as a solitary vagrant in search for a suitable territory and a partner (Negi 2014).

Throughout their range, the population of the golden jackal declined until the 1960s due to habitat fragmentation, culling practices and intensive hunting persecutions. During the 1980's, number of golden jackals increased in the core area and from the end of the century the dispersion of the species increased towards the North and West of Europe (Kryštufek & Tvrtković 1990, Krofel & Potočník 2008, Lapini et al. 2009, Arnold et al. 2012, Trouwborst et al. 2015, Hatlauf et al. 2016, Ranc 2016). Some studies suggested that natural causes and anthropogenic influences as well as the presence of other top predators, especially established wolf packs, can influence their patterns of fast dispersion and establishment in new territories (Giannatos et al. 2005, Šálek et al. 2014, Newsome et al. 2015, Trouwborst et al. 2015, Krofel et al. 2017). Nevertheless, the main reasons that can clearly justify this mesocarnivore release theory are still unclear. Known densities vary according to

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differences in habitat and mainly food availability, but there is little quantitative information along their full range (Sillero-Zubiri et al. 2004, Arnold et al. 2012, Hayward 2017).

Aiming to bring a clear notion about the definite situation of the golden jackal in Slovakia, we created a compilation of all official occurrences. The presence and establishment of the golden jackal can represent a great challenge for local authorities and decision makers (Trouwborst et al. 2015), due to their capacity for long-distance dispersion (Rutkowski et al. 2015) and the rapid growth of individuals in a very short period of time (Ivanov et al. 2016).

The results presented in this review represent crucial up-to-date information about past migration patterns, mortality data and actual distribution in the country. In addition, attempts will be made to provide a greater understanding of its distribution and expansion trends in order to support and guide future research of the golden jackal in Slovakia.

Material and Methods

We carried out an intensive analysis in official databases and we research available literature, to gather all certified data about golden jackals. Official records were collected from two governmental organisations, the State Nature Conservancy of the Slovak Republic (SNCSR) – www.biomonitoring.sk and the National Forest Centre (NFC) – www.forestportal.sk. The data from SNCSR is compiled in the CIMS – Complex Information and Monitoring System. This web database is specialised in online collection of data directly from various types of collectors. The NFC database, corresponding to the data gathered from all hunting grounds, mainly shot and observed individuals, is assembled annually and used in the production of the official hunting statistics. Literature research targeted scientific articles, non-published literature, websites from hunting groups, publications in hunting magazines and relevant personal communications.

Classification of collected evidence was done based on the assessment criteria from SCALP (Breitenmoser et al. 2006), adapted by GOJAGE (Hatlauf et al. 2016). Within this review, shot and found dead individuals were classified as C1 and registered observations as C3. We did not classify any evidence with the category of C2. Records that presented footprints and scats were not used for the assessment of the data.

Data was divided in three specific temporal periods. The first dataset aimed to understand and identify the probable migration patterns, using the geographic

locations of the data from the first official records until 2008. The second dataset gathers C1 evidence from 2009 until 2016, from hunting bags and found dead individuals. We generated a map with ArcGIS software, to understand the spatial distribution of the mortality records of the species in Slovakia. Within the third dataset, we generated a Kernel Density Estimation (KDE) analysis, using all C1 and C3 data from 2012 until 2016 (Silverman 1986, Worton 1989, Fleming & Calabrese 2016). We intended to present the spatial frequency of the species, producing an estimative model with the probable permanent range of the species in Slovakia. KDE was generated with ArcGIS software, C1 data was set as the main population field and C3 data as location points to reinforce C1 data.

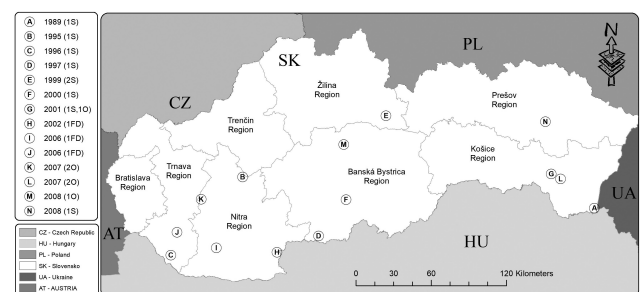


Fig. 1. Distribution of the first data set of records by year (S – shot, FD – found dead, O – observed).

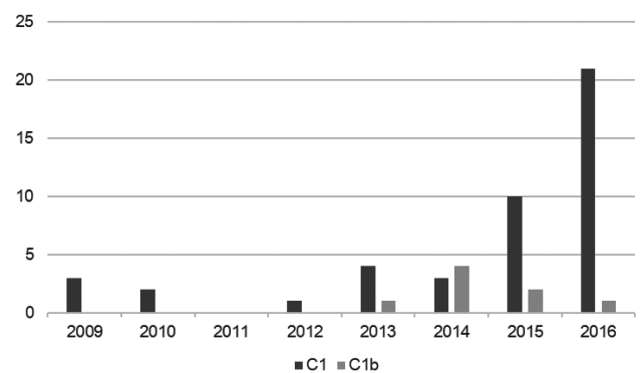


Fig. 2. Mortality data from 2009 until 2016, of shot (C1) and found dead individuals (C1b).

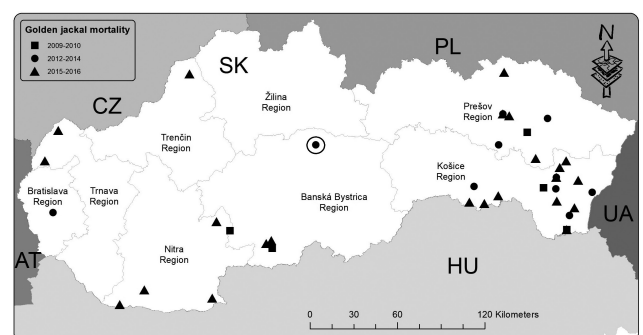


Fig. 3. Distribution of mortality – C1 data – from golden jackal 2009-2016.

Table 1. Data collected from golden jackal in Slovakia in the period 1989-2008 (* – dead resulting on vehicle collision; HU-Hungary; UA-Ukraine, AT-Austria; NLC-Nacional Forest Centre database).

Year	Code	District	Locality	Cardinal points	Proximity to border	Shot	Found dead	Observed	Source
1989	A	Trebišov	Čierna nad Tisou	Southeast	< 6 km HU-UA	1	0	0	Mošanský 1995
1995	B	Zlaté Moravce	Zlatno	West	< 60 km HU	1	0	0	Hell & Bleho 1995, Hell & Rajský 2000, Rajský & Nagy 1998, Rajský et al. 2005
1996	C	Dunajská Streda	Gabčíkovo	Southwest	< 6 km HU	1	0	0	Hell & Bleho 1995, Hell & Rajský 2000, Rajský & Nagy 1998, Rajský et al. 2005
1997	D	Veľký Krtíš	Dolinka	South	< 3 km HU	1	0	0	Hell & Bleho 1995, Hell & Rajský 2000, Rajský & Nagy 1998, Rajský et al. 2005
1999	E	Liptovský Mikuláš	Kráľova Lehota	North Centre	< 75 km HU	2	0	0	NLC 1999 (unpublished data)
2000	F	Trebišov	Leles	East	< 10 km HU-UA	1	0	0	NLC 2000 (unpublished data)
2001	G	Trebišov	Leles	Southeast	< 10 km HU-UA	1	0	1	Danko 2012, Balaskovics et al. 2013
2002	H	Levice	Zalaba-Pastovce	South	< 5 km HU	0	1	0	Danko 2012
2006	I	Nové Zámky	Nový Gág	Southwest	< 25 km HU		1*		Balaskovics et al. 2013
	J	Trnava	Trnava	Center	< 45 km HU-AT	0	1*	0	
	K	Nitra	Báb	Southeast	< 64 km HU-AT			2	
2007	L	Trebišov	Trebišov	Southeast	< 15 km HU < 34 km UA	0	0	2	Danko 2012, NLC 2007 (unpublished data)
	M	Dunajská Streda	Gabčíkovo	Southwest	< 3 km HU < 34 km AT			1	
2008	N	Banská Bystrica	Banská Bystrica	Center	< 65 km HU	0		1	Danko 2012
	O	Vranov nad Topľou	Bystré	East	< 44 km HU < 62 km UA	1		0	

Results

418 evidences of golden jackals were gathered from all available records, distributed by shot, found dead and observed individuals. It is important to refer that within all the records there is no certified information about breeding pairs.

The first literary reference of golden jackal in Slovakia is from 1947 from four individual pelts, one adult and three sub-adults found in Bratislava (Ferianc 1955, Feriancová-Masárová & Hanák 1965, Sládek & Mošanský 1985, Danko 2012). Given that their origin is unclear, this evidence was not used in any dataset.

The first certified record of the golden jackal was registered in 1989 (Mošanský 1995). Evidence from the first dataset comprehends nine golden jackals shot, three found dead (two in vehicle collisions) and seven observed individuals (Table 1). The location

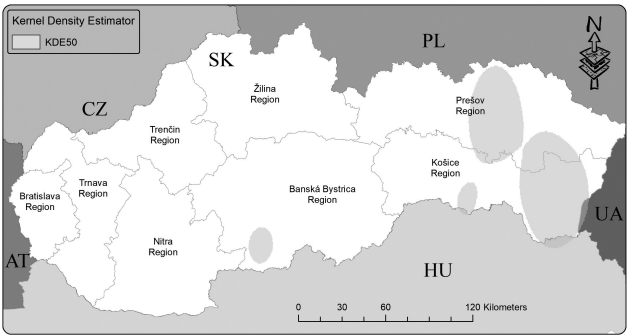


Fig. 4. Kernel density estimation of 50 % with C1 data as population field.

of the data is distributed all over Slovakia with the majority being in the South near the border with Hungary, others near the border with Ukraine and few not so far from the border with Austria. Spatially, these records reflect the most probable corridors used

in the dispersion and expansion of this species into Slovakia (Fig. 1).

In the second dataset, we gathered all shot (C1) and found dead (C1b) records (Fig. 2). In fact, it was from 2009 that the number of evidence of shot golden jackals became more frequent and increased steadily. Between 2009 and 2014, thirteen golden jackals were shot. In 2015, ten specimens were shot and in 2016 the numbers ascend to twenty-one, representing the highest number of specimens shot in one year. Thus, this depicts the increase of the dispersion of the species throughout the country (Fig. 3).

Within this dataset there were eight individuals found dead, six from animal vehicle collisions and two individuals without any clues for the cause of death. The distribution patterns are more consistent in the southern and eastern parts, but the data collected is widespread through the country (Fig. 3). Of interest, due to its location, is that from all data collected one individual was shot near Valaská in 2014 (black circle in Fig. 3).

In the fourth dataset, for the production of the KDE map, we merged 47 points from C1 category as the main data with 363 points from C3 category as presence data. Based on 50 % of the total of the data, KDE50, the map represents the main areas of frequency of presence, resulting in two large areas in the East and two smaller areas, one in the East part of the country and the other in the South of the central part of Slovakia (Fig. 4).

Discussion

The results obtained from all the official presence data collected on the golden jackal are very consistent and they reinforce the fact that the golden jackal is a permanent species in Slovakia (Urban et al. 2016, 2017, Guimarães et al. 2017). Although, due to the absence of registered data or available references before 1947 in any Slovak literature, there is a high probability that the golden jackal was not part of Slovak fauna in the past. Thus, increasing the probability that it dispersed naturally into the country, supported by the registered presence of the jackal in Hungary near the border (Szabó et al. 2009, Tóth et al. 2009). The fact is that from 1947 until 2008, there were only 13 registered occurrences of golden jackals representing the first official records of presence of the species in Slovakia (Fig. 1). It is important to understand the strong probability that their presence in Slovakia (Fig. 3) is a result of natural dispersion following the European expansion, not only of this species but also of all large carnivores (Arnold et al. 2012, Trouwborst et al. 2015).

With the data resulting from the KDE50 (Fig. 4), it is possible to predict areas with permanent occupancy, helping us understand the traits and possible limitations they face in the Slovak landscape, especially when the collection of evidence is done systematically in consecutive years.

In recent years, with the rapid growth of the golden jackal population in Hungary, studies reveal that the pattern of dispersion is towards North and West (Tóth et al. 2009, Arnold et al. 2012, Trouwborst et al. 2015, Hatlauf et al. 2017). In the spatial representation of the C1 records, from 2009 until 2016 (Fig. 3), it is possible to identify that golden jackals are found more in the South and presumably reside in the Southeast. It also reinforces the patterns of migration into Slovakia from Hungary and Ukraine (Volokh et al. 1998, Szabó et al. 2009, Zagorodniuk 2014).

In the last decade, distribution of the golden jackal and the numbers of individuals recorded in Slovakia (Fig. 2) enhance the need for a sustainable management program of the species to avoid possible consequences associated with their establishment and in order to deliver accurate estimate numbers of the population. There is still a large gap in information throughout the evidence regarding its presence and, thus, it is necessary to determine and differentiate whether we have identified the presence of a vagrant or stable population in some parts of the country.

The golden jackal's increasing presence and more probable establishment in Slovakia can represent a great challenge for local authorities and decision makers (Trouwborst et al. 2015). Population can increase in a short period of time (Ivanov et al. 2016), assisted by their capacity for long-distance dispersion (Rutkowski et al. 2015). Competition between the golden jackal and the red fox (*Vulpes vulpes*), and an impact on other species which inhabit common habitats, can probably be expected (Lanszki & Heltai 2002, Lanszki et al. 2006, 2010, Markov & Lanszki 2012, Ćirović et al. 2014, Kowalczyk et al. 2015, Penezić & Ćirović 2015).

The presence of the three large carnivores in Slovakia (*Ursus arctos*, *Canis lupus* and *Lynx lynx*) can be a limiting factor for the expansion and establishment of the species through the entire country as described in other countries (Newsome et al. 2015, Krofel et al. 2017). The interaction between species should be assessed and therefore further field surveys and other studies should be implemented.

This article review reveals that the presence of the golden jackal in Slovakia is more common and largely dispersed throughout the territory (Urban et al. 2016, Guimarães et al. 2017). All this knowledge

will be useful to support the elaboration, approval and implementation of the necessary care program for the golden jackal in Slovakia, including the introduction of monitoring to bring further knowledge of the status of the species (Guimarães et al. 2017, Urban et al. 2017).

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