

REVIEW

Current status and distribution of golden jackals *Canis aureus* in Europe

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ABSTRACT

1. The golden jackal *Canis aureus* is one of the most widespread canid species with a range covering areas of central, eastern and southern Europe, northern Africa and parts of Asia. Distribution of the golden jackal in Europe has been dynamic, including dramatic declines (until the 1960s), recovery (1960s and 1970s) and expansion (from the early 1980s onwards).
2. We present up-to-date information on golden jackal status in Europe and range expansion.
3. For data collection we reviewed the scientific literature and contacted scientists from the relevant countries. We distinguished between vagrant animals and established populations.
4. In the last decade, there has been an increase in jackal records in areas where the species has not been reported before. Increased presence is recorded northwards and westwards of the distribution range of the golden jackal, specifically in Hungary, Serbia and Slovakia. In Austria, the first case of reproduction was confirmed in 2007; reproduction has also recently been reported in Italy.
5. Results indicate an ongoing expansion in Europe's jackal population, with a particular spread of the Balkan populations towards central Europe. Although there are numerous reports of sightings, only few originate from confirmed sources and in many areas status is unknown or vague. There is a general lack of ecological data and almost no information on ecological consequences associated with the golden jackal expansion.

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INTRODUCTION

The golden jackal *Canis aureus* is one of the most widely distributed canid species and is found in many areas of Europe, Asia and Africa (Moehlman 1983, Sillero-Zubiri et al. 2004). Despite its widespread distribution, there is little quantitative information on jackal densities or distribution (Sillero-Zubiri et al. 2004). In Europe, jackal populations have undergone significant population changes in the past decades (Kryštufek et al. 1997), including changes in distribution and abundance. However, assessing the actual distribution of golden jackals is difficult as reports are often anecdotal, are published in local hunting magazines and are prone to remaining unverified by the scientific community (Kryštufek et al. 1997). In such reports, it is also difficult to differentiate between vagrant animals and established populations (Zachos et al. 2009).

In Europe, the golden jackal has typically been distributed in the Balkan region (Demeter & Spassov 1993, Kryštufek et al. 1997). Here golden jackals nearly became extinct in many areas during the 1960s due to habitat loss and persecution with poisoned baits (Spassov 1989). Core populations were found only in some scattered regions, for example, Strandja (Bulgaria and Turkey), the Dalmatian coast, Aegean Macedonia and the Peloponnesus (Spassov 1993, Giannatos 2004, Spassov 2007). Following legislative protection in 1962, the golden jackal initially re-colonized its former territories in Bulgaria (Spassov 1989) and became established in Romania and Serbia (Kryštufek et al. 1997). More recently, during the 1980s, individuals appeared in Italy, Slovenia, Austria, Hungary and Slovakia (Demeter 1984, Lapini & Perco 1988, Hoi-Leitner & Kraus 1989, Kryštufek & Tvrtkovič 1990, Lapini et al. 1993, Bauer & Suchentrunk 1995, Hell & Rajský 2000, Heltai et al. 2000). Current changes in distribution and population sizes are presumably a result of protected status and reduced persecution. Golden jackals are of particular interest to both conservationists (directive 92/43/EEC, Annex V, Anonymous 2007a) and game managers (as generalist predators), and are often regarded as invasive species. The species is not yet included in the Large Carnivore Initiative for Europe, showing a lack of attention for this adaptive colonizer. As populations of jackals appear to be spreading in Europe, we present a timely update on past reviews of jackal status in Europe (Demeter & Spassov 1993, Kryštufek et al. 1997, Mitchell-Jones et al. 1999), which will be a useful tool for both planning future conservation efforts and mitigation of human–wildlife conflicts.

METHODS

Our area of focus spreads from the Atlantic coast of Portugal westwards to Greece and the Bosphorus and northwards along the Black Sea coastline, to the Ukraine, Belarus and Baltic states in the east and along a north-south axis from Norway to Spain.

An intensive literature search was performed using search engines such as Web of Science and Google Scholar; golden jackal populations and occurrence of vagrant animals were compiled for European countries (Fig. 1).



Fig. 1. Approximate distribution of golden jackal populations in Europe. Dark shaded areas show established populations with reproduction. White dots indicate confirmed vagrant specimens, which represent the most north-western and north-eastern distribution areas of the golden jackal.

Where information was missing from peer reviewed literature, colleagues from scientific departments, federal agencies and non-governmental organisations from the relevant countries were contacted for detailed information.

We distinguished between vagrant animals (single confirmed records of jackal presence) and established populations (defined as clusters of reproducing animals independent of population size). For each country section we give recent information on jackal distribution in the context of the published accounts in the reviews of the 1990s (Demeter & Spassov 1993, Kryštufek et al. 1997, Mitchell-Jones et al. 1999). For countries where reliable current information is missing, we summarize status as last documented in the literature.

RESULTS

European countries with golden jackal presence and recent appearance are given in alphabetical order (see also Table 1). Results are also shown in the maps (Figs 1 and 2).

Albania

Golden jackal distribution in Albania remains cryptic. Published accounts dating back to the 1950s and 1960s report a distribution mainly along the coastline (Atanassov 1953, Heptner & Naumov 1974, Kryštufek et al. 1997). There are no recent accounts of jackal distribution in Albania, and the species seems to be close to extinction in this region (Giannatos 2004).

Austria

Since the late 1980s, immigrating individuals appeared in Austria, but there was no evidence of an established population. The first confirmed specimen in Austria was

Table 1. Status of golden jackal in European countries, classed as Vagrant animals (V)/Established population independent of population size but with confirmed reproducing animals (ES)/Unknown (U)

Country	Status	Location within country	First reported appearance	Population trend
Albania	U	West coast†	Unknown	Unknown
Austria	ES	East	1987	Increase
Bosnia	U	Unknown	Unknown	Unknown
Bulgaria	ES	Nearly whole country	Autochthon	Increase
Croatia	ES	West (coast)	2007	Increase
Czech Republic	V	Southwest	2006	Increase
Germany	V	East	1996	Unknown
Greece	ES	Coastlines south and west	Unknown	Decrease
Hungary	ES	South, northeast and northwest	1980*	Increase
Italy	ES	Northwest	1985	Increase
Republic of Macedonia	U	Unknown	End of 1980s*	Unknown
Montenegro	U	Unknown	Unknown	Unknown
Romania	ES	South	1931	Increase
Serbia	ES	Northwest	1983*	Increase
Slovakia	V	Southwest	1989	Increase
Slovenia	ES	Northeast and northwest	1952	Increase
Turkey (European part)	ES	West	Unknown	Unknown
Ukraine	ES	South	1998	Increase

*Re-colonization after extirpation.

†Last known appearances.



Fig. 2. Recent distribution of golden jackal in Bulgaria (after Spassov 2007 with additions by authors, unpublished data). Shaded areas denote moderate to low density; crossed areas indicate high density, patches to the west show isolated population clusters.

found in 1987 in Styria (Humer 2006). During the following years (1989–98), vagrants were sighted, shot or found dead in six of nine Austrian provinces: Carinthia, Styria, Burgenland, Upper and Lower Austria (Hoi-Leitner & Kraus 1989, Bauer & Suchentrunk 1995, Petrakovics 1996, Spitzenberger 2002). In 2006, a questionnaire of hunters was conducted which provided four unconfirmed records between 2004 and 2005 (Styria, Burgenland, Upper Austria), and a record of a shot specimen in 1996 (Upper Austria; Humer 2006). Furthermore, one confirmed specimen was found dead on the freeway A2 in Upper Austria in 2006 (Franz Suchentrunk & Theodora Steineck, pers. comm.). Plass (2007) reports three more records from 2003–05 which probably include two of the unconfirmed specimens from the questionnaire mentioned above, but also one shot golden jackal from the Wienerwald (Upper Austria) in 2003 (F. Spitzenberger in Plass 2007). Accordingly, a total of 17 confirmed and three unconfirmed golden jackal records exist for Austria between 1987 and 2007. In 2007, the first evidence of reproduction by golden jackals in Austria was reported in the Austrian-Hungarian border area near Lake Neusiedl (Anonymous 2007b). The presence of golden jackals in this area was also confirmed via a camera trap in spring 2009. However, it is not known what happened to the offspring born in 2007, or whether further reproduction occurred (Viktor Reinprecht, pers. comm.).

Bosnia and Herzegovina

As the country is surrounded by countries holding jackal populations, at least vagrant animals are likely. However, we lack current information on the status of the species in this area. The IUCN lists Bosnia and Herzegovina as an area of jackal presence (Jhala & Moehlman 2008).

Bulgaria

The core European population of the golden jackal is in Bulgaria. High densities of populations are situated in three main regions: (1) southeastern Bulgaria – from the Kamchia river basin and the Gulf of Burgas to the Turkish border to the south and from the Black Sea Coast to the Stara Zagora region to the west; (2) northeastern Bulgaria – in the region between Dobrudja and Tutrakan and (3) the central part of northern Bulgaria (the central region of the Bulgarian Danubian plain). There are no records of golden jackals from the mountainous regions of south-western and central Bulgaria, and populations are thought to be contiguous with the population of Greek Macedonia through the corridor of the Struma valley (Spassov 2007). Furthermore, the low and scarcely forested territories of the Eastern Rhodopes with low winter snow cover holds jackal populations (Evgenii Raychev unpublished data, Spassov & Markov 2004, Spassov 2007). Current populations of jackals are believed to be stable in Bulgaria. Based on analysis of hunting data, the total population in Bulgaria has been estimated as approximately 10000 (Spassov & Markov 2004, Spassov 2007). The expansion of the jackal in the late 1970s and the 1980s was related to the official protection of the species in the 1960s (Genov & Vassilev 1989), to the further prohibition of killing by poison, and to the development of game farming in this period, leading to increased food availability for this carnivore species. The recent human depopulation of the Bulgarian countryside is probably one of the main factors for the maintenance of the high density of the golden jackals today (Spassov 1989, 2007).

Croatia

Information on current distribution is scarce. Golden jackals have been confirmed in Dalmatia and Istria (Kryštufek et al. 1997, Krofel 2007, 2008). However, there are no current data on density or specific distribution.

Czech Republic

The first confirmed male golden jackal was reported in 2006 (Koubek & Červený 2007). The animal was found dead close to a road in southern Moravia, near the Austrian and Slovakian border region.

Germany

Möckel (2000) reported the first evidence of golden jackals in Germany. A male golden jackal had been confirmed in southern Brandenburg from 1996 until it was shot in 1998. There are no further confirmed records of golden jackal.

Greece

Jackal populations declined between the early 1970s and 1980s, due to poisoning campaigns and intensive hunting (Giannatos et al. 2005). As a result, in 2010 the distribution of golden jackal remains discontinuous and fragmented in Greece (Giannatos 2004), and populations occur in seven split subareas located in Evros, Vistonida-Nestos, Serres, Halkidiki, Fokida, Peloponnesus and Samos (Giannatos 2004). Each subarea contains one to nine jackal population clusters and each population consists of one to 42 territories. The estimated number of golden jackals in Greece according to survey data from 2000–01 was 1000 individuals (Giannatos et al. 2005); the highest density was estimated to occur in Vistonida-Nestos: 30 individuals per 1000ha (Heltai et al. 2007). Kryštufek et al. (1997) documented in their review the presence of golden jackals on the Ionian Islands, particularly Leukas and Kephallina. However, presence of golden jackals on the Ionian islands cannot be confirmed in 2010 (Giorgos Giannatos, pers. comm.).

Hungary

Until it became extinct in the country in the first half of the 20th century, the golden jackal was indigenous to Hungary. Beginning in the early 1980s, immigrating individuals re-appeared in former territories, and this led to the re-establishment of a viable population in 1991–92 (Szabó et al. 2009). Since then, golden jackals have formed three distinct subpopulations in three counties (Bács-Kiskun, Baranya, Somogy) in the southern region of Hungary (Heltai et al. 2000). Heltai et al. (2000, 2004) report a significant increase of killed jackals in hunting bags from 1997 (11 shot) to 2004 (95 shot). Populations have continued to increase (Szabó et al. 2009), and the core of jackal distribution is still located in the south; dispersing individuals are found spreading out to the west, north and east. As there are no apparent limiting habitat factors, it is likely that this expansion will continue (Szabó et al. 2009). In the core areas, the highest density (estimated by acoustic survey) was 13.3 individuals per 1000ha (Szabó et al. 2008). In 2007, the population in Hungary was estimated to be 1510 individuals, indicating a doubling of the population since 2004 (Tóth et al. 2009) and 16 years after the first breeding pair was observed in the southern border of the country close to Croatia.

Italy

In Italy, the species has been present at least from 1985 (in the Pozzuolo del Friuli area, Udine; Lapini et al. 2009). However, instead of a fragmented population, the golden jackals occurred as vagrant individuals, presumably originating from Slovenia and from the Istrian peninsula (Kryštufek et al. 1997). In 2010, range expansion is detectable in the Julian Pre-Alps. A vagrant animal has been confirmed in the area of Venice (Lapini et al. 2009). New data from 2009 confirmed the golden jackal in the north, specifically in the Bolzano-Bozen province and South Tyrol; moreover, reproducing family groups have been reported (Lapini et al. 2009).

Republic of Macedonia

Kryštufek et al. (1997) reported that the golden jackal became extinct in Macedonia during the first half of the 1960s. There is only one account of a vagrant animal since that time (Kryštufek & Petkovski 1990). The location of the country next to Bulgaria, which has an expanding golden jackal population, makes records of jackals in the near future likely.

Moldova

In 2010, the golden jackal was not regarded as part of the Moldavian carnivore fauna (Munteanu & Lozanu 2004). However, as the population in Romania is spreading it can be expected that vagrant animals will appear in near future.

Montenegro

Golden jackals have been confirmed in the south, near the Albanian boarder at the coast (Ada island, Schneider-Jacoby 2004). Sackl et al. (2006) report three jackals killed on the main road (E-65) between the airport of Tivat and the village of Dub in 2002 and 2003.

Romania

According to Almasan (1995) and Murariu and Munteanu (2005), stable populations of golden jackals have been found since 1984 in the area of Niculitel (southeast of Dobrogea), as well as in the Danube Plain located in the southern part of the country. Irregular presence was also reported for Braşov in the centre of the country. Further spreading along the rivers Pruth and Siret is possible (see also Kryštufek et al. 1997). Small groups of golden jackals roam in the Danube Delta. We estimate a total population size of approximately 600 golden jackals all over Romania (authors, unpublished data 2010).

Serbia

In Serbia, the north-eastern border with Bulgaria, and the Lower Srem are the main areas of the golden jackal's distribution. Large populations are located in the vicinity of Negotin and Bela Palanka in the northeast of the country. Since 2000, 500 specimens were shot in the vicinity of Negotin alone. From this area, jackals have spread into the Velika Morava river valley. The second population in Lower Srem has expanded along the banks of river Sava to the slopes of Fruška Gora (Milenkovic & Paunovic 2003). Recent findings indicate that both jackal populations are genetically very similar and suggest strong founder effects (Zachos et al. 2009).

Slovakia

Four jackals were shot between 1989 and 2001, near Cierna, near Tisou and Lucenec, not far from the Hungarian border. In 2008, there were unconfirmed sightings from

Banska Bystrica. If these can be confirmed, they are the first jackal records from central Slovakia (Robin Rigg, pers. comm.).

Slovenia

In 2005, a female jackal was shot in Northern Slovenia, in the Upper Savinja Valley (Krofel & Potočník 2008). Jackals had been reported since 1952 (Brelj 1955) and some were observed or shot since then, mostly on the border with Croatia (Krofel 2008).

Turkey (European part)

Golden jackals are present along the coasts of the Black Sea and Aegean Sea, but not in the central steppe plateau (Kryštufek et al. 1997).

Ukraine

There have been reports of golden jackals in southern Ukraine (Rozhenko & Volokh 2000). In 2010, approximately 70 jackals roamed in the Odessa region (Alina Mishta, pers. comm.). Recent accounts suggest that jackals occur up to the reserve Biletskiy Plavni (Poltava region, Ruzhilenko 2008).

DISCUSSION

Our review shows that expansion of golden jackals in eastern and central Europe is ongoing. Recent confirmation of vagrant animals indicates expansion from the Balkan population northwards and westwards. The expanding populations in Bulgaria, Serbia and Hungary suggest a further spreading towards central Europe. Confirmed specimens from adjacent countries in the north of the Balkan population confirm this trend. It is possible that animals from Istria are also spreading northwards, as golden jackals have appeared in Italy and Slovenia and have formed reproducing family groups (Lapini et al. 2009). Recent findings show that a vagrant animal from Austria was genetically indistinguishable from Serbian jackals (Zachos et al. 2009). This example shows that genetic comparison of vagrant animals with animals from established populations can help to identify routes of expansion. However, such comparison has, unfortunately, not been done so far, and in many cases routes of expansion of golden jackals in Europe are not clear. We therefore suggest that populations of golden jackals should be monitored genetically, in order to identify source populations (Veit et al. 2005) and routes of expansion (Manel et al. 2003).

Abundance of jackals in southern Europe is not clear for many areas. The golden jackal population in Greece is relatively well documented. Threats are mainly linked to fragmentation of habitats and persecution (Giannatos 2004), and management measures are needed to secure the long-term survival of jackals in Greece (see Giannatos 2004). Outside Greece, golden jackal abundance in the Adriatic region remains largely unclear. There is a general lack of current information on density and population trends, especially for Bosnia and Macedonia.

It is likely that climatic changes due to global warming will reduce barriers to the dispersal of jackals, such as long winters with severe snow cover (Giannatos 2004). Migration along water bodies (Szabó et al. 2006) allows long-distance spreading (Demeter & Spassov 1993), and the absence of the natural predator of golden jackals, the wolf *Canis lupus*, is likely to influence expansion positively (Kryštufek & Tvrtković 1990, Giannatos 2004).

Recent developments in golden jackal distribution show that this species finds favourable habitat in eastern and central Europe. It is therefore likely that the golden jackal will return to areas where it formerly became extinct. The golden jackal has great colonising potential, and it is foreseeable that it will continue to spread in Europe; it may even appear in regions where it has not been native before.

It is of concern, that background data remain poor. With the exception of Greece, golden jackal distribution in south-eastern Europe is unclear. This lack of knowledge makes it hard to assess population dynamics and future range development, particularly as golden jackal populations in southeastern Europe are supposed to be a source for populations in central Europe.

Surprisingly, despite its success and spread during the last years, the golden jackal has not been of great interest for carnivore researchers or for non-governmental organisations in central Europe. Hence, our ecological background knowledge remains restricted (Giannatos 2004). There is a need to investigate the development of golden jackal distribution, as it provides a unique opportunity to observe the reaction of communities to a novel generalist predator under the influence of different types of habitat. The golden jackal occurs in a wide range of different habitats covering a variety of ecosystems (Mitchell-Jones et al. 1999). We have recently started to discover details of jackal ecology in Europe (e.g. Lanszki & Heltai 2002), and it is important to establish basic background data on behavioural and ecological plasticity displayed in newly colonized habitats. With our current knowledge, identifying and applying suitable conservation and management actions is hardly possible. We therefore strongly suggest that monitoring and research activity should be intensified for this species, and that results should be published in peer-reviewed journals.

REFERENCES

- Almasan H (1995) Şacalul în fauna României (The jackal in the Romanian fauna). *Vânătorul şi pescarul român* 1: 18–19.
- Anonymous (2007a) *Canis aureus*. In: IUCN 2007. European Mammal Assessment IUCN <http://ec.europa.eu/environment/nature/conservation/species/ema/>
- Anonymous (2007b) Die Rückkehr des 'Rohrwolfs'. Der Goldschakal (*Canis Aureus*). Nationalpark Neusiedler See-Seewinkel. *Geschnatter* 3: 3.
- Atanassov N (1953) Untersuchungen über die Schakale (*Canis aureus* L.) in Bulgarien. *Izvestia na Zoologicheskia institute. Bulgarska Akademia na naukite* 2: 189–273.
- Bauer K, Suchentrunk F (1995) Weitere Ausbreitung des Goldschakals *Canis aureus* L., 1758 in Österreich. *Zeitschrift für Säugetierkunde* 60: 307–309.
- Breljih S (1955) Šakali (*Canis aureus* L.) na ozemlju Slovenije. *Biološki Vestnik* 4: 56–58.
- Demeter A (1984) Recent records of rare or non-resident large carnivores in Hungary. *Vertebrata Hungarica* 22: 65–71.
- Demeter A, Spassov N (1993) *Canis aureus* L. 1758–Schakal, Goldschakal. In: Stubbe M, Krapp F (eds) *Handbuch Der Säugetiere Europas*, Vol. 3: 107–138. Aula-Verlag, Wiesbaden, Germany.
- Genov P, Vassilev S (1989) Der Schakal (*Canis aureus* L.) in Bulgarien. Ein Beitrag zu seiner Verbreitung und Biologie. *Zeitschrift für Jagdwissenschaft* 35: 145–150.
- Giannatos G (2004) *Conservation Action Plan for the Golden Jackal (Canis Aureus L. 1758) in Greece*. WWF Greece, Athens, Greece.
- Giannatos G, Marinos Y, Maragou P, Catsasorakis G (2005) The golden jackal (*Canis aureus* L.) in Greece. *Belgian Journal of Zoology* 135: 145–149.
- Hell P, Rajský D (2000) Immigrationen des Goldschakals in die Slowakei im 20. Jahrhundert. *Beiträge zur Jagd- und Wildforschung* 25: 143–147.
- Heltai M, Szemethy L, Lansky J, Csanyi S (2000) Returning and new mammal predators in Hungary: the status and distribution of the golden jackal (*Canis aureus*), racoon dog (*Nyctereutes*

- procyonoides) and racoon (*Procyon lotor*) in 1997–2000. *Beiträge zur Jagd- und Wildforschung* 26: 95–102.
- Heltai M, Szucs E, Lanszki J, Szabó L (2004) Az aranyakál (*Canis aureus* Linnaeus, 1758) új előfordulásai Magyarországon (The golden jackal's new occurrences in Hungary). *Állattani Közlemények* 89: 43–52.
- Heltai M, Giannatos G, Szabó L, Lanszki J (2007) Golden jackal (*Canis aureus*) past-present distribution and current status in northern (Hungary) and southern (Greece) limits of its European range. In: Billinis C, Kostoulas P (eds) *Proceedings of the 5th International Congress on Wild Fauna*, The Wild Animal Vigilance Euromediterranean Society, Calkidiki, Greece.
- Heptner VG, Naumov NP (eds) (1974) *Die Säugetiere Der Sowjetunion*. Gustav Fischer Verlag, Stuttgart, Germany.
- Hoi-Leitner M, Kraus E (1989) Der Goldschakal, *Canis aureus* (Linnaeus 1758), in Österreich (Mammalia austriaca 17). *Bonner Zoologische Beiträge* 40: 197–204.
- Humer A (2006) *Goldschakale in Österreich. Aktueller Status und Managementstrategien unter besonderer Berücksichtigung der Einstellung und des Wissens zum Thema Goldschakal bei österreichischen Bezirksjägermeistern*. Diploma Thesis, Institute of Wildlife Biology and Game Management, University of Natural Resources and Life Sciences, Vienna, Austria.
- Jhala YV, Moehlman PD (2008) *Canis Aureus*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.2. <http://www.iucnredlist.org>
- Koubek P, Červený J (2007) The Golden Jackal (*Canis aureus*) – a new mammal species in the Czech Republic. *Lynx (Praha)* 38: 103–106.
- Krofel M (2007) Golden jackal (*Canis aureus*, L.) on the Pelješac peninsula (southern Dalmatian, Croatia). *Natura Croatica* 16: 201–204.
- Krofel M (2008) Survey of golden jackals (*Canis aureus*) in Northern Dalmatia, Croatia: preliminary results. *Natura Croatica* 17: 259–264.
- Krofel M, Potočnik H (2008) First record of a golden jackal (*Canis aureus*) in Savinja Valley (Northern Slovenia). *Natura Slovenia* 10: 57–62.
- Kryštufek B, Petkovski S (1990) New record of the jackal *Canis aureus* Linnaeus, 1758 in Macedonia (Mammalia, Carnivora). *Fragmenta Balcanica Musei Macedonici Scientiarum Naturalium* 14: 131–138.
- Kryštufek B, Tvrkovič N (1990) Range expansion by Dalmatian jackal population in the 20th century (*Canis aureus* L., 1758). *Folia Zoologica* 39: 291–296.
- Kryštufek B, Murariu D, Kurtonur C (1997) Present distribution of the Golden Jackal *Canis aureus* in the Balkans and adjacent regions. *Mammal Review* 27: 109–114.
- Lanszki J, Heltai M (2002) Feeding habits of golden jackal and red fox in south-western Hungary during winter and spring. *Mammalian Biology* 67: 129–136.
- Lapini L, Paolo M, Dorigo L, Are G, Beraldo P (2009) Reproduction of the golden jackal (*Canis Aureus* Moreoticus i. Geoffroy Saint Hilaire, 1835) in Julian Pre-Alps, with new data on its range expansion in the high-adriatic hinterland (Mammalia, Carnivora, Canidae). *Bollettino del Museo Civico di Storia naturale di Venezia* 60: 169–186.
- Lapini L, Perco F (1988) Lo sciacallo dorato (*Canis aureus*, L. 1758) specie nuova per la fauna Italiana (Mammalia, Carnivora, Canidae). *Gortania – Atti Museo Friuli Storia Naturale* 10: 213–228.
- Lapini L, Perco F, Benussi E (1993) Nuovi dati sullo sciacallo dorato (*Canis aureus* L. 1758) in Italia (Mammalia, Carnivora, Canidae). *Gortania – Atti Museo Friuli Storia Naturale* 14: 231–238.
- Manel S, Schwartz MK, Luikart G, Taberlet P (2003) Landscape genetics: combining landscape ecology and population genetics. *Trends in Ecology and Evolution* 18: 189–197.
- Milenkovic M, Paunovic M (2003) Phenomenon of Golden Jackal (*Canis aureus* L., 1758) Expansion in Serbia. Meeting Report of the Carpathian Workshop on Large Carnivore Conservation. Braşov, Romania.
- Mitchell-Jones AJ, Amori G, Bogdanowicz W, Kryštufek B, Reijnders PJH, Spitzenberger F, Stubbe M, Thissen JBM, Vohralík V, Zima J (eds; 1999) *The Atlas of European Mammals*. Academic Press, San Diego, USA.
- Möckel R (2000) Ein Goldschakal (*Canis aureus*) in Südburgenland – Erstnachweis für Deutschland. *Säugetierkundliche Informationen* 4: 477–481.
- Moehlman PD (1983) Socioecology of silver-backed and golden jackals, *Canis mesomelas* and *C. aureus*. In: Eisenberg JF, Kleiman DG (eds) *Recent Advances in the Study of Mammalian Behavior*, 5: 423–453. American Society of Mammalogists, Lawrence, Kansas, USA.
- Munteanu A, Lozanu M (2004) Lumea animala a Moldovei. Mamifere, Vol. 4. Stiinta, Moldova.

- Murariu D, Munteanu D (2005) *Fauna României*. Vol. XVI. Fascicula 5. Mammalia, Carnivora. Editura Academiei Române, Bucharest, Romania.
- Petrakovics G (1996) Goldschakal im Burgenland erlegt. *Anblick* 5: 22–23.
- Plass J (2007) Dokumentation einer zweiten Einwanderungswelle des Goldschakals *Canis aureus* Linnaeus, 1758 in Österreich aus den Jahren 2003–06. *Beiträge zur Naturkunde Oberösterreichs* 17: 55–68.
- Rozhenko NV, Volokh AM (2000) Appearance of the golden jackal (*Canis aureus*) in the south of Ukraine. *Vestnik Zoologii* 34: 125–129.
- Ruzhilenko NS (2008) Trends of species composition, spatial distribution and abundance changes in carnivorous mammals of Middle Pridnieprovja in XX – beginning XXI century//Environment XXI. Proceedings of IV international conference, 9–10 October 2008, Dnipropetrovsk, Ukraine.
- Sackl P, Schneider-Jacoby M, Stumberger B (2006) The importance of the Tivat Salina (Montenegro) for migrating and wintering waterbirds, including some notes on passerines. *Annales-Series Historia Naturalis* 16: 267–278.
- Schneider-Jacoby M (2004) *Basic Ideas for the Development of Sustainable Tourism on the Ada Island Ulcinjska Primorje – Montenegro*. Euronatur, Radolfzell, Germany.
- Sillero-Zubiri C, Hoffmann M, Macdonald DW (2004) *Canids: Foxes, Wolves, Jackals and Dogs: Status Survey and Conservation Action Plan*, 2nd ed. IUCN Canid Specialist Group, Gland, Switzerland and Cambridge, UK.
- Spassov N (1989) The position of Jackals in the *Canis* genus and life-history of the Golden Jackal (*Canis aureus* L.) in Bulgaria and on the Balkans. *Historia Naturalis Bulgarica* 1: 44–56.
- Spassov N (1993) The jackal. *Ecocurrer* 3: 40–41.
- Spassov N (2007) The Jackal, *Canis aureus* (Linnaeus 1758). In: Miteva S, Mihova B, Georgiev K, Petrov B, Vansink D (eds) *The Mammals, Important for Conservation in Bulgaria*, 6: 234–238. Dutch Mammal Society VZZ, Arnhem, the Netherlands.
- Spassov N, Markov G (2004) Biodiversity of large mammals (Macromammalia) in the Eastern Rhodopes (Bulgaria). In: Beron P, Popov A (eds) *Biodiversity of Bulgaria*, 2. Biodiversity of Eastern Rhodopes (Bulgaria and Greece). Pensoft & Nat. Mus. Natur. Hist, Sofia, Bulgaria.
- Spitzenberger F (2002) Die Säugetierfauna Österreichs (Grüne Reihe des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft). Austria Medienservice, Graz, Austria.
- Szabó L, Heltai M, Lanszki J (2006) A Tisza, mint zöld folyosó szerepe az aranyakál magyarországi terjedésében. (The role of the River Tisza as a green corridor in to the spreading of golden jackal in Hungary). *Vadbiológia* 12: 47–54.
- Szabó L, Heltai M, Lanszki J (2008) Factors that influence the Golden jackal's (*Canis aureus* L. 1758) spreading in Hungary. 92nd Annual Meeting of the German Society of Mammalogy. Vienna. Abstracts of Oral Communications and Poster Presentations. *Mammalian Biology Special Issue* 73: 41.
- Szabó L, Heltai M, Szucs E, Lanski J, Lehoczki R (2009) Expansion range of the golden jackal in Hungary between 1997 and 2006. *Mammalia* 73: 307–311.
- Tóth T, Krecsák L, Szücs E, Heltai M, Huszár G (2009) Records of the golden jackal (*Canis aureus* Linnaeus, 1758) in Hungary from 1800th until 2007, based on literature survey. *North-West Journal of Zoology* 5: 386–405.
- Veit ML, Robertson RJ, Hamel PB, Friesen VL (2005) Population genetic structure and dispersal across a fragmented landscape in cerulean warblers (*Dendroica cerulea*). *Conservation Genetics* 6: 175–174.
- Zachos FE, Cirovic D, Kirschning J, Otto M, Hartl GB, Petersen B, Honnen AC (2009) Genetic variability, differentiation, and founder effect in golden jackals (*Canis aureus*) from Serbia as revealed by mitochondrial DNA and nuclear microsatellite loci. *Biochemical Genetics* 47: 241–250.

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