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Short communication

The re-establishment of the golden jackal (*Canis aureus*) in FYR Macedonia: Implications for conservation

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ABSTRACT

Golden jackals have been expanding across Europe in recent decades. In the former Yugoslav Republic (FYR) of Macedonia they have been considered extinct since the 1960s. Using a questionnaire survey and a camera trap study we provide the first unequivocal evidence for the re-establishment of the species in the country. The questionnaire survey indicated that golden jackals were present in the western and possibly present in the eastern parts of the country. The camera trap study recorded golden jackals on 155 occasions in central and north-western FYR Macedonia; five different individuals were identified, including one pup, while most jackal images were recorded during the night and morning hours. The results of the study are set in context to the limited information on the status and biology of the species and the urgent need for effective management and conservation actions for the golden jackal in FYR Macedonia.

Wildlife has been celebrating an impressive comeback in Europe recently, with several wildlife populations expanding in range and increasing in numbers (Deinet et al., 2013). The golden jackal (Canis aureus) is a medium-sized carnivore (Sillero-Zubiri et al., 2004) and one of the most widespread canids in the world (Arnold et al., 2012; Jhala and Moehlman, 2015). In Europe, the distribution of the species has been dynamic, including dramatic declines (until the 1960s), recovery (1960s and 1970s) and expansion (from the early 1980s onwards) (Arnold et al., 2012). In recent years golden jackals have moved out of the Balkans to recolonize numerous countries, such as Hungary (Szabó et al., 2009), with vagrants reaching as far west as Switzerland and as far north as Poland and Estonia (Kowalczyk et al., 2015; Trouwborst et al., 2015). Despite these population recoveries there is a general lack of ecological data and information on the distribution of the golden jackal in Europe and almost no information on the ecological consequences associated with the expansion of the species (Sillero-Zubiri et al., 2004; Arnold et al., 2012).

Prior to World War II the golden jackal was present in the former Yugoslav Republic (FYR) of Macedonia mainly in the southern parts of the country, bordering to Greece (Milenković, 1987). After the war, intense human persecution in the mid-1960s led to the extermination of the species (Kryštufek and Petkovski, 1990). Since then the golden jackal has been recorded in FYR Macedonia only twice, in 1989 and in 1996 (Kryštufek and Petkovski, 1990; Kryštufek and Petkovski, 2002); all major studies over the past two decades evaluating the status of the species in Europe have reported the golden jackal as being extinct (Kryštufek et al., 1997; Arnold et al., 2012) or as having a sporadic and very limited distribution in the country (Rutkowski et al., 2015; Trouwborst et al., 2015).

Following circumstantial evidence of the presence of the golden jackal in FYR Macedonia since 2000 (Macedonian Ecological Society, unpublished data) a preliminary study was initiated to evaluate the presence of the species in the country. The results of the study are set in context to the limited information on the status and biology of the species and the urgent need for effective management and conservation actions for the golden jackal in FYR Macedonia.

The presence of the golden jackal was evaluated mainly in the forested, mountainous parts of FYR Macedonia. FYR Macedonia is dominated by a rugged topography with high mountain peaks ranging between 2300–2800 m. Forests at lower altitudes (700–900 m) are dominated by Italian oak (*Quercus frainetto*) and Turkey oak (*Q.*

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cerris), and at medium altitudes (900–1500 m) by oaks (*Quercus* sp.) and beeches (*Fagus* sp.). Forests in the subalpine zone (>1500 m) are dominated by beeches and conifers (*Pinus* sp.). Apart from the golden jackal the local fauna includes all three large carnivores of southern Europe [i.e., brown bears (*Ursus arctos*), wolves (*Canis lupus*), and lynx (*Lynx lynx*)] (Melovski et al., 2013).

Golden jackal presence in FYR Macedonia was evaluated initially with a questionnaire survey. The survey was conducted in 2006–2010 within the framework of the Balkan Lynx Recovery Programme (Breitenmoser et al., 2008) and targeted therefore primarily areas considered to represent suitable lynx habitat (Melovski et al., 2013). For the survey, FYR Macedonia was divided in 10 × 10 km cells (Fig. 1), from which a total of 116 cells were selected, covering approximately 11,600 km^2. In each cell at least one village was randomly selected to represent the results inside that given cell. In each village we aimed to interview up to eight residents: two respondents were randomly selected, while the remaining six were selected among people considered most likely to have wildlife encounters (i.e., hunters, game wardens, foresters, shepherds, livestock breeders, beekeepers etc.) (Melovski et al., 2013). Questionnaires were carried out in person and consisted of questions aimed at obtaining information about golden jackal presence based on sightings, indirect signs of jackal presence (i.e., scats, tracks, dens), killed and/or hunted individuals and human–jackal interactions. Whenever possible, interviewed people were asked to specify the geographic locations and the dates of jackal sightings and interactions with humans. Jackal presence in each cell was estimated based on the respondents' answers: we considered that no positive answers in the questionnaire indicated that the species was possibly not present in the area; 1–50% positive answers indicated that golden jackals were possibly present in a given cell, while 51–100% positive answers were considered to indicate jackal presence.

Golden jackal presence in FYR Macedonia was investigated in 2014–2015 using also white-flash, motion-triggered camera traps (Cuddeback, Ambush). The camera traps were programmed to take pictures continuously and were set up in two different study areas (Fig. 1): (A) Study area 1: The first study area was approximately 70 ha and was located in a lowland marsh area which is part of the Jasen Protected Area. Six cameras were deployed randomly at different locations, in order to cover different habitat types: arable land, forest and wetland. Cameras were deployed along hiking trails and roads and operated continuously from 30/05/14–17/09/14. (B) Study area 2: The second study area was located in the Mavrovo National Park in north-western FYR Macedonia. The 332 km^2 large study area was divided into thirty 2.5 × 2.5 grid cells and was monitored using 60 cameras. Cameras were installed in every second cell (Zimmermann et al., 2007) selecting the most promising sites along game paths, hiking trails and forest roads and operated continuously from 12/03/15–10/05/15. In both study areas, animal activity was categorized as morning (03:00–08:59), midday (09:00–14:59), evening (15:00–20:59) and night (21:00–02:59).

A total of 740 people were interviewed (2006 $N = 228$; 2007 $N = 407$; 2009 $N = 84$; 2010 $N = 21$). Golden jackals were considered to be possibly present ($N = 39$; 33%) or present ($N = 6$; 5%) in 45 cells in the country, representing an area of approximately 4,500 km^2. Golden jackals were considered to be present in the western and possibly present in the eastern parts of the country (Fig. 2). Jackals were considered to be possibly not present in 62% of the cells investigated (Fig. 2).

The camera traps operated for a total of 2422 trapping nights (Study area 1: 629 trapping nights; Study area 2: 1793 trapping nights) and recorded golden jackals on 155 occasions [6.4 occasions/100 trapping nights; Study area 1: 154 occasions; Study area 2: 1 occasion]. On most occasions 148; 96% single jackals were recorded; only on 7 occasions (4%) two or more jackals were recorded. Most captures occurred during the night (71 occasions; 46%) and morning (45 occasions; 29%) hours, whereas 26 (17%) and 13 (8%) occasions occurred in the evening and in the midday respectively. Based on external morphological features (i.e., body size, reproductive status, fur colouration) a minimum of five different individuals (4 adult-sized individuals, 1 pup) were identified (Fig. 3A, C, D) and on three occasions jackals were observed to have caught birds (Fig. 3B).

Population recoveries are of particular interest to conservation biologists, not only because of their ecological effects (Hobbs et al., 2013), but also because of the challenges they create for management and policy. This is particularly true for carnivores, such as the golden jackal that are often associated with livestock conflicts (Stoyanov, 2012; Redpath et al., 2013).

The golden jackal went extinct in FYR Macedonia in the mid-1960s and has been considered to be extinct or only occasionally present in the country since then (Kryštufek et al., 1997; Arnold et al., 2012; Rutkowski et al., 2015; Trouwborst et al., 2015). We provide unequivocal evidence of the re-establishment of the golden jackal in FYR Macedonia, mainly through the results of a camera trap study and the recording of a reproductive family group in study area 1. The golden jackal recorded in study area 2 is possibly a vagrant, as, despite the increased photo trapping efforts throughout study area 2 in various types of habitat, it was the only individual recorded. This fact is in accordance with the results of the questionnaire survey, which indicated that golden jackal presence was most probable in the western and in the eastern parts of the country. The results of the questionnaire study should be viewed however with caution due to the inherent limitations of this methodology (White et al., 2005), including the fact that presence/absence of a species in the results of a questionnaire does not necessarily imply actual presence/absence of the species in the area, as it might go undetected and vice versa. The results of our questionnaire need to be verified through systematic field work focusing on the collection of data on actual presence, i.e., direct observations or collection of indirect signs of presence (e.g., scats, tracks, dens).

It is difficult to determine when and from where golden jackals recolonized FYR Macedonia: potential source animals might have arrived from Bulgaria and/or Greece, two neighbouring countries with significant golden jackal populations (Giannatos et al., 2005; Stoyanov, 2012; Rutkowski et al., 2015). The species most likely did not arrive from Serbia or Kosovo as golden jackals are absent from the southern parts of these countries (Paunović et al., 2008). Given however the limited amount of information on golden jackal presence in FYR Macedonia we can not disregard the possibility that the species might have survived undetected in the country.

Through the images captured by the camera traps we were able to carry out some interesting opportunistic observations. We recorded single jackals having caught prey (i.e., birds) on three different occasions. Birds have been recorded in the diets of golden jackals in neighboring Greece (Lanszki et al., 2009), Bulgaria (Stoyanov, 2012) and Serbia (Ćirović et al., 2014), but appear not to play locally a significant role in the diet of the species. We recoded also golden jackal activity throughout the day, with a significant proportion of images captured during night and early morning hours, which is in accordance to the general activity patterns of the species recorded in Bulgaria (Georgiev et al., 2015).

The re-establishment of the golden jackal in FYR Macedonia has important implications for nature conservation, research and management in the country. Considering that our study did not cover the entire country and focused mainly on forested and mountainous areas, thus leaving out areas with suitable golden jackal habitat (e.g., valleys, lowlands) (Paunović et al., 2008), it is probable that golden jackals have re-established themselves in other parts of FYR Macedonia as well. A systematic field study covering the entire country is necessary to evaluate the distribution of