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Short communication

Golden jackal expansion in Europe: First telemetry evidence of a natal dispersal

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ABSTRACT

The Eurasian golden jackal (*Canis aureus*) is currently undergoing a rapid range expansion. Originally restricted to small coastal areas of the Mediterranean and Black seas, this highly adaptive and generalist species is now reproducing throughout Southeastern and Central Europe. In addition, individuals are being seen further to the North and West. This continental-scale phenomenon is receiving high interest among the public and policy makers. Although dispersal is a key determinant of the species expansion, little is known about the dispersal ecology of the species. Here we report the first direct evidence of the golden jackal dispersal ability by presenting the natal dispersal of a yearling female monitored by GPS-telemetry in Southwestern Hungary. We used a cluster-based path segmentation analysis to identify the different movement sequences: pre- and post-dispersal home ranges, dispersal event as well as explorative forays. The yearling female left her natal home range before the mating season, in January and settled 61.2 km to the North, where she successfully bred. The dispersal transience lasted for 12 days, with a cumulative travelled distance of 223.7 km through a human-dominated landscape (including two crossings of a motorway). The dispersal movements were characterized by much longer step lengths than observed during the home ranging behavior, and a high propensity for nocturnal movements. Noticeably, the dispersal event followed a period of numerous explorative forays. Our GPS telemetry study confirms the golden jackal's ability to disperse long distances through human-dominated landscapes, and the potential for the species to expand further in human-dominated landscapes of Central Europe.

The Eurasian golden jackal (*Canis aureus*) is currently undergoing a remarkable range expansion. Restricted to small coastal areas of the Mediterranean and Black seas in the Holocene (Sommer and Benecke, 2005), this highly adaptive and generalist species is now reproducing throughout Southeastern Europe (Arnold et al., 2012; Trouwborst et al., 2015). In addition, vagrant individuals are being noticed further to the North and West – as far as the Baltic countries, in Denmark, Switzerland and The Netherlands (Rutkowski et al., 2015; Trouwborst et al., 2015). The species expansion could potentially have important consequences on communities and ecosystems (Lanszki et al., 2006; Ćirović et al., 2016), and is already receiving high interest from the public and policy-makers (Trouwborst et al., 2015). Uncovering the processes underlying the species range expansion and forecasting its future developments are therefore of ecological interest and management priorities.

Dispersal affects the redistribution of organisms, and is thus a key determinant of species range expansions (Jønsson et al., 2016). Insights on golden jackal dispersal ecology are scarce, and have largely relied on indirect approaches. First, opportunistic detection of vagrant individuals, and in some cases the development of geographically isolated populations, illustrate the species dispersal abilities (Arnold et al., 2012; Rutkowski et al., 2015). Second, large-scale genetic investigations in Europe support the occurrence of long-distance dispersal in the species (Rutkowski et al., 2015). With development of new tracking methods such as GPS-telemetry, opportunities arise to investigate animal dispersal in a more direct manner (Jønsson et al., 2016). For example, such data have recently

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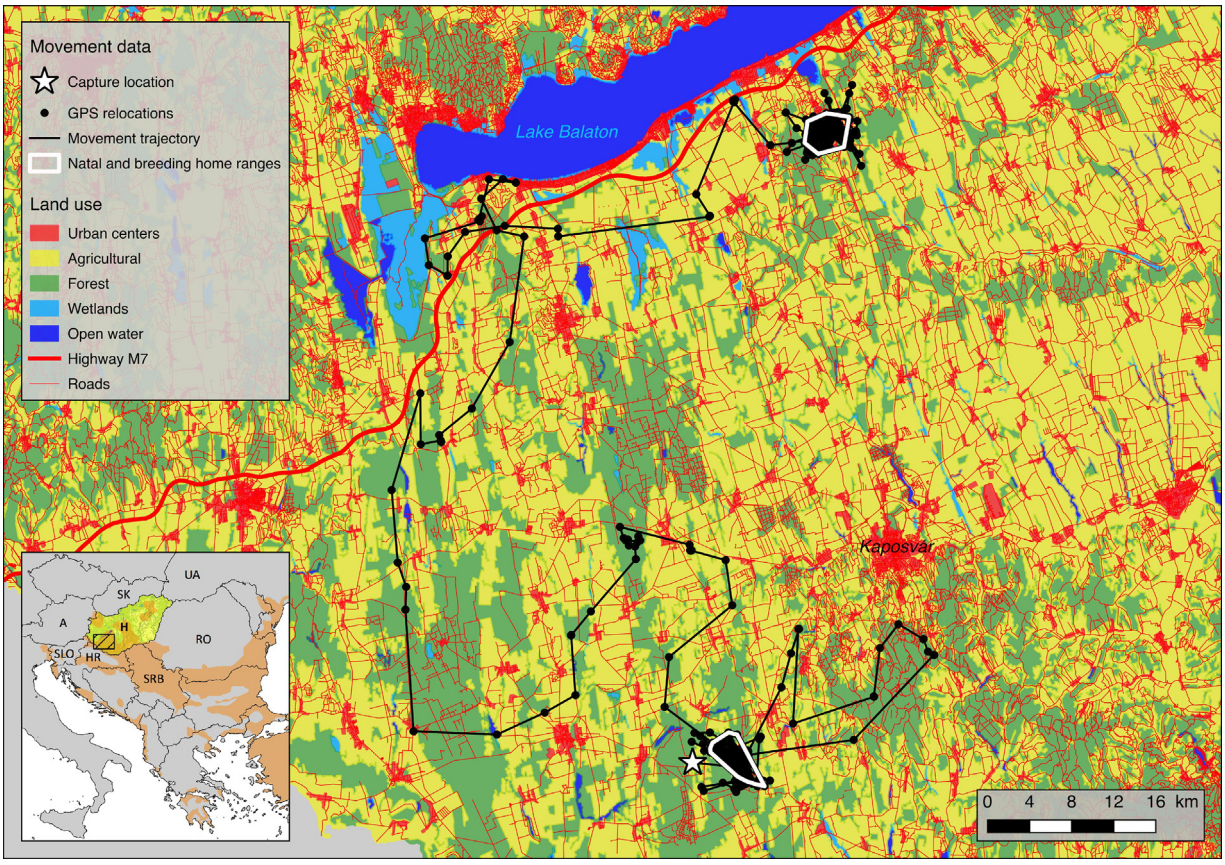

Fig. 1. Dispersal event of Zsuzsi, a GPS-collared female golden jackal in SW Hungary. Zsuzsi was captured (white star) close to her natal home range (bottom white polygon). She dispersed (trajectory: black dotted line) to her breeding home range (top white polygon), 61.2 km away. During the dispersal transience, she crossed the M7 motorway (thick red line). Bottom-left overview panel: the study area (black hatched rectangle) is located on the Northern edge of the golden jackal distribution (pale orange; Trouwborst et al., 2015) in Hungary (H). Neighboring countries are as labeled as follow: Austria (A), Slovakia (SK), Ukraine (UA), Romania (RO), Serbia (SRB), Croatia, (HR) and Slovenia (SLO). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

shed light on this phenomenon in European grey wolf (Ciucci et al., 2009; Ražen et al., 2016; Wabakken et al., 2007). Here we report the first direct evidence of the golden jackal dispersal ability by presenting the long-distance natal dispersal of a yearling female monitored by GPS-telemetry.

The study was conducted in south-western Hungary (Fig. 1), an area of lowland and low hills characterized by a temperate continental climate. The landscape is composed of broadleaf woodlands (mean cover within the county: 29%) interspersed within an agricultural matrix (53%) and small settlements. It is traversed by the M7 motorway. Golden jackal presence has been continuous in the study area since 1995 and the population is currently expanding northwards (Heltai et al., 2000; Szabó et al., 2009).

On 21 October 2013, we captured a female golden jackal (nicknamed "Zsuzsi") near Lábod village (N46.196, E17.513) using a box trap baited with big game viscera. We immobilized the animal using 0.1 ml DexDomitor (agent: 1 mg/ml dexmedetomidine hydrochloride, *i.m.*). She was estimated to be 1.5 years-old, mature, non-breeding, intact, weighed 10.1 kg and was in good body condition. We fitted Zsuzsi with a GPS Plus Mini (270 g; Vectronic Aerospace) collar programmed to acquire relocations at 00:00, 03:00, 06:00, 12:00, 18:00, 21:00 and 22:00 (CET), and to relay data via Global System for Mobile Communications (GSM). We monitored her movements for 238 days, she was legally shot on 16 June 2014.

We used a path segmentation analysis to objectively identify the dispersal event. To this end, we first subsampled the movement trajectory to a homogeneous fix interval of 6 h between GPS relocation attempts (i.e., at 00:00, 06:00, 12:00 and 18:00). We used MigrO (Damiani et al., 2015, 2016), a spatiotemporal clustering-based segmentation algorithm, to categorize the movement path into three distinct phases: residence (i.e., pre- and post-dispersal home ranges), excursion forays (i.e., movements away from and returning to a single home range) and dispersal event (i.e., transience movements between the pre- and post-dispersal home ranges). MigrO relies on two density criteria – the threshold distance ϵ defining neighbor locations and the number of neighbors n to classify a point as a core point. A cluster is formed by an ensemble of core points (and all other locations within their radii ϵ) and is classified as a dense region when the animal's minimum continuous presence within the cluster exceeds δ (see Damiani et al., 2015 for details). We defined points as neighbors if they were closer than the average distance covered by the animal during 6 h (ϵ = median step length, i.e. 474 m) in order to link the definition of neighborhood distance to the movement capacity of the animal. We classified points as core points if there was at least one full day of activity within their neighborhood radius ϵ ($n = 4$). Finally, we categorized a cluster as a dense region if the animal was present for at least a month ($\delta = 30$ days) – a duration that was set a priori to capture home range phases but omit restricted use areas resulting from the exploitation of localized resources.

We delineated the pre- and post-dispersal home ranges as the minimum convex polygons (MCP) encompassing all relocations identified by MigrO for the respective dense regions. We measured the net dispersal distance as the Euclidean distance between departure and settlement locations, defined as centroids of the