Polar Biology
https://doi.org/10.1007/s00300-022-03037-0

SHORT NOTE

The first record of the golden jackal (*Canis aureus* Linnaeus, 1758) in the Russian Subarctic

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Received: 22 November 2021 / Revised: 16 March 2022 / Accepted: 17 March 2022

Abstract

The range of the golden jackal (*Canis aureus* Linnaeus, 1758) in Eurasia has undergone significant changes over the past decades, revealed in species expansion and range extensions. The article summarizes literature characterizing the dynamics of the species' range in Russia, and presents data on appearances of animals far outside established ranges. Here we present the first record of the golden jackal in the northern taiga subzone of Russia in an agriculturally undeveloped region, far beyond the species' range and its presumed ecological preferences. Species identification was confirmed by morphological and craniometrical examinations, and genetic analysis. This jackal mitochondrial DNA haplotype is associated with populations from Europe and Caucasus. The article suggests the possible routes for the jackal's travel to this geographical location (64°40′20″ N, 43°22′56″ E) and discusses the possibility of the species inhabiting subarctic areas with severe climatic conditions. Moreover, the authors speculate on the phenomenon of range expansion of the golden jackal.

Keyword Golden jackal · Range expansion · Dispersal · Northern taiga

Introduction

The current distribution of the golden jackal in Russia is much wider than it used to be in the twentieth century, when the species occurred in a relatively narrow strip along the northeastern coast of the Black Sea, on the western coast of the Caspian Sea as far as Makhachkala City, and along some river valleys to the west of the Caspian Sea, but no higher than 1000 m above sea level in mountainous areas (Heptner et al. 1967). The golden jackal now populates almost the entire North Caucasian region—from the Caspian Sea to the Sea of Azov. It has spread northwards to the Rostov and Volgograd Regions (Kudaktin et al. 2019). According to the web portal Mammals of Russia (RUSMAM), golden jackals occur in the Voronezh, Saratov, and Orenburg Regions. Their numbers in the Caucasus have increased (Yarovenko et al. 2014; Kudaktin et al. 2019). Golden jackals were noted even much further north. For example, in 2007 an adult male jackal was shot in the Leningrad Region (59°40′41″ N, 30°43′23″ E), and an adult female was killed in 2016 in the Moscow Region (54°19′23″ N, 38°37′14″ E) (Blokhina et al. 2018; RUSMAM). As for the appearance of the jackal in the Leningrad Region in 2007, it is appropriate to provide some background. The animal could have arrived from neighboring Estonia, where breeding pairs have been observed. However, the first golden jackal encounter in Estonia was documented in 2013 (Männil et al. 2014). The European distribution of the golden jackal has been changing markedly in the new millennium—this carnivore has been sighted in geographic locations where it had not occurred before. The species has been reported in Austria, Poland, Czech Republic, Belarus, Baltic countries, Germany, and Denmark, as well as in Finland and even Norway (Arnold et al. 2012; Weingarth et al. 2012; Stratford 2015; Trolle 2015; Hatlauf et al. 2017; Paulauskas et al. 2018; Honkala and Nummi 2019; Kowalczyk et al. 2020; Ree 2021; Sørensen and Lindsø 2021).

Encounters of the animals far beyond their historical range bring up questions—will they be able to establish resident populations in the novel environments, and what were the dispersal routes used?

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Published online: 07 April 2022

Materials and methods

A male golden jackal was legally trapped in the Arkhangelsk Region (Russia), outskirts of Tsimola Village (64°40′20″ N, 43°22′56″ E) on 24 February 2021 (Fig. 1). The leg-hold trap was deployed by hunter to catch bold wolves that had visited the cattle farm slaughter site. The area between the farm and the forest is a grassland some 100 ha in size.

The species was identified on examination by body measurements, the general color of the fur, and the adnate of the pads of the middle toes (Fig. 2). Generally accepted basic craniometrical measurements were made using Vernier

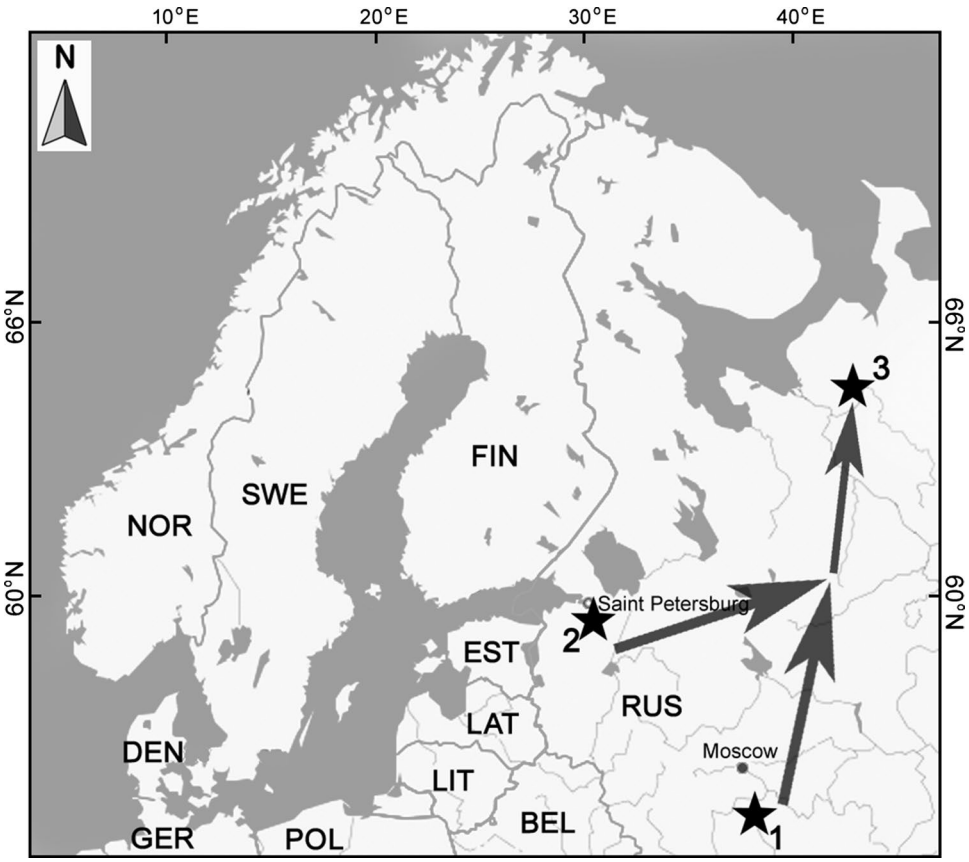

Fig. 1 Jackal occurrences (stars with numbers) in European Russia: (1) Moscow Region 2016 (Blokhina et al. 2018), (2) Leningrad Region 2007 (RUSMAM), (3) Arkhangelsk Region 2021, and possible pathways (half dark arrows) of golden jackal (*Canis aureus*) arrival in location 3 (2021)

Fig. 2 Golden jackal (*Canis aureus*) from the Arkhangelsk Region (64°40′20″ N, 43°22′56″ E) on 24 February 2021: **a** the general appearance of the animal, **b** the hair from the back, **c** connate pad of the forepaw, **d** highlighted head

caliper (Novikov 1956; von den Driesch 1976; Stoyanov 2019).

Genomic DNA was extracted from a tissue sample using Qiagene DNeasy Tissue kit (Qiagen, Germany) according to the manufacturer's protocol. Mitochondrial DNA control-region sequencing was performed as described by Fabbri et al. (2014). The 460-bp-long sequence of the mtDNA obtained was revised manually and aligned using the ClustalW algorithm in MEGA11 (Tamura et al. 2021) with golden jackal sequences from GenBank. As a result, we obtained 35 homological sequences of the 240-bp mtDNA control region (CR). Phylogeny reconstruction was conducted using software MEGA11 with the neighbor-joining statistical method (Saitou and Nei 1987) and 1000 bootstrap replications. The evolutionary distances were computed using the Tamura–Nei method (Tamura and Nei 1993) and are in the units of the number of base substitutions per site.

The mtDNA sequence amplified in this study was uploaded to GenBank (accession number OL323053).

Results and discussion

The jackal carcass we examined did not appear emaciated; the brownish-red fur was thick and uniform. Hair on the back was marked by bands of color (Fig. 2). The morphometric parameters of the trapped jackal were within the ranges common in this species (Novikov 1956; Heptner et al. 1967; Bošković et al. 2015). Measurements: weight, 10.1 kg; length (cm), total 80, trunk 55, head 20, tail 27. Skull measurements (Online Resource 1) also corresponded to those of an adult male (Novikov 1956; Stoyanov 2019). The 460-bp fragment of the mtDNA CR we obtained from the jackal (OL323053) was identical to the reference golden jackal mtDNA CR haplotype previously identified in Hungary, Italy, Croatia, Serbia, Bulgaria, Ukraine, Poland, Lithuania, Turkey, and the Caucasus (Randi et al. 2000; Rueness et al. 2011; Fabbri et al. 2014; Pilot et al. 2014; Kowalczyk et al. 2015; Ibis et al. 2015; Rutkowski et al. 2015; Paulauskas et al. 2018; Shakarashvili et al. 2020). The analyzed specimen (OL323053) had the greatest affinity with European and Caucasian haplotypes and was most distantly separated from Indian ones (Fig. 3). This is not surprising and could be due to the rather high genetic uniformity of jackals in Europe (Zachos et al. 2009; Fabbri et al. 2014).

The question arises of where this golden jackal killed so far north came from. Village Tsimola is situated on the right-hand bank of the River Pinega in the northern taiga subzone. Following two general directions of expansion of the species from the south of Russia and from southwest Europe (Kudaktin et al. 2019; Spassov and Acosta-Pankov 2019), we find there are two possible pathways the jackal could have taken to this place: from the south Vologda Region, or from the west or southwest Leningrad Region, where the species has been encountered before (Fig. 1). Whichever the case, the carnivore had to cover the last stretch moving along the Pinega River valley, since the territory north and northeast of the Northern Dvina River lower course is the White Sea-Kuloi plateau, which is heavily paludified, with karstified areas in the eastern part. Floodplains of the rivers with their riparian and insular meadow communities interspersed with willow stands seem to be the most suitable for jackals as an ecological corridor (Vereshchagin and Dyunin 1949; Spasov 1989).

How could such a relatively small carnivore survive the winter in the sparsely populated northern taiga? Deep snows, extreme cold, and large forested massifs were considered as factors limiting the spread of the jackal population to the north (Vereshchagin and Dyunin 1949; Krofel et al. 2017; Spassov and Acosta-Pankov 2019). Having identified this question, it makes sense to give a short description of weather conditions at the time jackal appeared. In December, the snow thickness was 20 cm, and by March it reached 61 cm, all this time remaining loose, making movements difficult for many animals. The average monthly temperatures of in December, January, and February were lower than the long-term monthly average and were −9.1 °C, −16.4 °C, and −20.8 °C, respectively (Pogodaiklimat). Analyzing the potential ecological drivers of jackals' survival in the area, one should mention that there is a small cattle farm operating there. Thus, it is possible that anthropogenic factors contributed to the jackals' survival. Other studies have suggested the presence of the wolf (*Canis lupus*) as a factor limiting the spread of the golden jackal (Giannatos et al. 2005; Šálek et al. 2014; Krofel et al. 2017). Some authors name, although tentatively, the wolf among the jackal's enemies (Heptner et al. 1967), and a wolf killing a jackal has been reported (Mohammadi et al. 2017). On the other hand, we cannot ignore facts such as the two species cohabiting areas, their simultaneous settlement in previously unoccupied territories, and their parallel population growth, which suggest a transition from an antagonistic to a tolerant relationship (Guimarães et al. 2019; Kudaktin et al. 2019). In this particular case, it should be noted that the night the jackal was trapped, the location was also visited by a pair of wolves. The study area is inhabited by large mammalian carnivores, including brown bear (*Ursus arctos*), lynx (*Lynx lynx*), wolverine (*Gulo gulo*), and wolf, with the latter showing an upward population trend in the past decade (Rykov 2021).

A more important issue is to understand why jackals are being found further and further north, far beyond their historical range (Rutkowski et al. 2015; Linnell et al. 2021). Is this part of a global trend of southern animal species moving into northern habitats owing to climate changes and anthropogenic transformation of ecosystems? We tend to think of the golden jackal's arrival in the Arkhangelsk Region, in

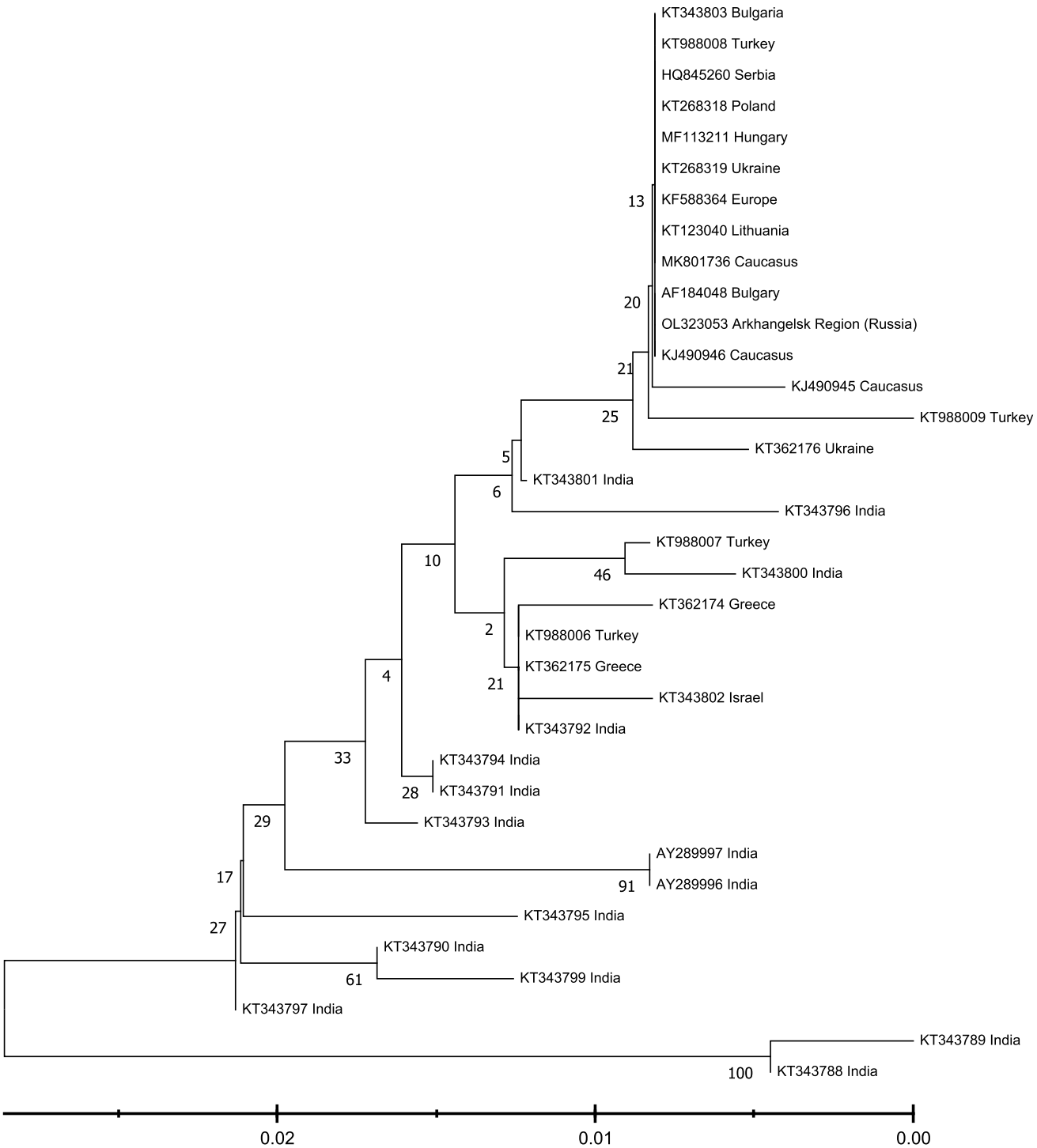

Fig. 3 Neighbor-joining tree based on 240-bp sequences of mtDNA CR from our study (OL323053) and GenBank. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) is shown next to the branches. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. GenBank accession number KF588364 with location "Europe" includes fragment of 450 bp of the hypervariable domain of the mtDNA CR1 from 120 golden jackals collected in Bulgaria, Croatia, Serbia, and Italy

northern taiga, as well as in Finnmark (Norway), as a phenomenon of the species' expansion—when animals reach beyond their historical distribution—and more globally as an event of so-called population waves. In the twentieth century, similar events in the European North of Russia were observed with roe deer (*Capreolus capreolus*) (Danilov et al.

2017) wild boar (*Sus scrofa*) (Danilov et al. 2018), and even moose (*Alces alces*) (Nygren et al. 2008).

Considering the severe climatic conditions in the north taiga and the low level of animal husbandry and agriculture, there is no reason to expect that the golden jackal will be able to establish a breeding population in this area.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00300-022-03037-0.

Acknowledgements The authors thank Olga Kislova for translating this article, John Hechtel for English revision, and Luigi Boitani for proofreading it. We are also grateful to Lyudmila Topchieva and Olga Balan for their advice regarding genetic analysis. We acknowledge the reviewers of the manuscript, Rafał Kowalczyk and Jennifer Hatlauf. The authors are especially grateful to A. Lobanov for providing biological material from the jackal carcass.

Author contributions AR received the biological material, made measurements of the animal, and prepared analytical data collection for the article. KT defined the species, prepared a review of publications, and wrote the article together with AR and AK. AK performed genetic analysis.

Funding The study was carried out under state order no. FMEN-2022–0003.

Data availability All biological materials collected by the authors are stored in the Pinega State Nature Reserve and Karelian Research Centre of the Russian Academy of Sciences. The obtained sequence of CR mtDNA was submitted to GenBank (accession number OL323053).

Code availability Not applicable.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The research followed all relevant laws and ethical standards. The capture of the animal by the hunter was carried out on his own initiative and in accordance with the legislation in force in the field of hunting in the Russian Federation.

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