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Golden jackal expansion in northernmost Europe: records in Finland

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Abstract

The Eurasian golden jackal (*Canis aureus*) has been rapidly expanding its distribution range in Europe. Whether jackals will be able to adapt to new environmental conditions in northern Europe remains largely unresolved. Herein we provide additional evidence for the species' ability to colonize northern environments by presenting the new records of golden jackal occurrence in Finland. During 2018–2022, golden jackals were recorded at six localities of which one located in southern, four in central and one in northern Finland. We drafted potential main routes of dispersal movements by jackals in northern Europe, and discuss ecology and management of this newly colonizing species in Finland.

Keyword Mesocarnivore · Range expansion · Long-distance dispersal

The Eurasian golden jackal (*Canis aureus*) has been rapidly expanding its distribution range in Europe (Trouwborst et al. 2015; Krofel et al. 2017; Hatlauf et al. 2021; Ranc et al. 2022). Native to Europe but initially limited to small areas along the Mediterranean and Black Sea coasts of southeastern Europe, golden jackals have undergone a continental-scale range expansion during the twentieth century, possibly accelerating during the last 20 years (Spasov 1989; Krofel et al. 2017). The scale and spatiotemporal patterns of golden jackal expansion resembles that of two American canid mesocarnivores—the coyote (*Canis latrans*) (Hody and Kays 2018) and the crab-eating fox *Cerdocyon thous*. In the case of golden jackals (and of coyotes), strong evidence exists for the role of historical wolf decline in the species expansion (Krofel et al. 2017; Newsome et al. 2017), yet other mechanisms (e.g., changes in land use, in management practices

and global warming) may be playing important roles as well (Šálek et al. 2014; Rutkowski et al. 2015; Cunze and Klimpel 2022). The species now reproduces throughout Southeastern and Central European countries, with dispersers reaching far into western and northern Europe (Ranc et al. 2022). Up to date, golden jackals have been reported in 34 European countries, 11 of which have been newly colonized since 2010 (Hatlauf et al. 2021; Sørensen and Lindsø 2021).

The golden jackal is a highly adaptable generalist species, characterized by a large diet breadth, with small mammals and scavenging being consistently important food sources (Lanszki et al. 2022). Jackals use and breed in very diverse environmental conditions, with highest densities observed in heterogeneous agricultural environments and wetlands (Šálek et al. 2014). The species also appears particularly successful in human-dominated environments (Ćirović et al. 2016; Lanszki et al. 2018; Fenton et al. 2021). Vagrants are capable of long-distance dispersal, including in highly anthropized landscapes (Rutkowski et al. 2015; Lanszki et al. 2018), suggesting that most of the continent could be colonized in the near future. The rapid range expansion and the regular occurrence of vagrants far from the known core distribution provides evidence of high dispersal capacity; however, the dispersal ecology of the species remains largely unknown (Lanszki et al. 2018).

Whether golden jackals will be able to adapt to new environmental conditions, especially in the northern countries, is unresolved. However, the recent establishment of a growing population in Estonia (although limited to coastal areas), suggests that the species could indeed thrive in Boreal

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ecosystems (Männil and Ranc 2022) despite the ecological conditions there significantly differ from those in the source populations of Southeastern and Central Europe, and of the Caucasus. In addition, several dispersing individuals have very recently been noticed as far as the European Subarctic and Arctic regions, in Norway and in Russia (Sørensen and Lindsø 2021; Rykov et al. 2022). Herein we provide additional evidence for golden jackal's ability to colonize northern environments by presenting the records of jackal presence in Finland and discuss potential dispersal routes into Finland by taking into account the geographic location of occurrences. Furthermore, we discuss the future of golden jackal and its management in Finland.

The monitoring of large carnivore populations in Finland is extensively based on opportunistic point observations (sightings, tracks, roadkills) by hunters, foresters and naturalists; then verified and recorded by approximately 2000 volunteer large carnivore contact persons distributed all over the country (Kojola et al. 2018). Persons for this network are nominated in local game management districts ($n=280$) and educated by Finnish Wildlife Agency and Natural Research Institute Finland. In addition, thousands of private trail cameras used for local wildlife monitoring are maintained by hunters, providing an additional, important source of opportunistic data. Suspected trail camera images of golden jackals are sent to wildlife experts working for Natural Resources Institute Finland for assessment. Hunters, naturalists and large carnivore contact persons are encouraged to send images that could be jackal images. The images sent are mostly images of fox or wolf. After this first filtering during which the authenticity is evaluated by Finnish specialists, potential golden jackal records are evaluated by several European golden jackal experts. Our data here comprise records from six different locations, originating from different data sources—trail camera images (three), picture from photographer (one), recovery of dead animal (one) and multiple data from the presence of one possibly resident individual (snow tracks, vocal records; see Table 1 and Fig. 1 for record summary and location). In this article, we present a photographic document (Fig. 1), the date, the type

of the document and surrounding environment (Table 1), for each record.

We detail below the records in their chronological order. The first verified record of a golden jackal in Finland dates of August 5th 2018, when an individual was photographed by a trail camera within a house yard near Kajaani, in east-central Finland. Second, a few months later, on January 16th 2019, a single golden jackal was photographed by another trail camera at feeding site in a coniferous forest near Reisjärvi, in central Finland. Third, on July 23rd 2019, a jackal moving along the road side was photographed from car in Rautavaara (a municipality neighboring Kajaani; i.e. 90 km from the first record). Fourth, the presence of one individual was repeatedly reported, between November 22nd 2020 and April 16th 2022, by a trail camera located at a roe deer feeding station Lumijoki–Siikajoki, west-central Finland. The same individual, probably a male (cf. Table 1), may have also been observed nearby by an ornithologist on September 1st 2022. Fifth, in early March 2022, a jackal was inadvertently trapped (and killed) by a fox-snare in Lapland 120 km north from the Arctic Circle (northernmost record in Finland). The individual was a male that weighed 10 kg and proved out to be in good physical condition based on laboratory investigation by Finnish Food Authority (personal communication). The species identification was confirmed in DNA analysis (J. Aspi et al., unpublished data). The potential relatedness of this animal to Estonian jackals is not known. Sixth and finally, snow tracks and spontaneous vocalizations by a single jackal have been reported in late March 2022, in southeastern Finland, near the Russian border (Fig. 1). Despite the accumulating data (records #4 and #6) and in the absence of additional information on these two areas of repeated occurrences, the most plausible scenario is that an individual has settled in each area. Further efforts should be conducted to ascertain the identity of the individuals and evaluate the unlikely, but possible, occurrence of territorial (reproductive) groups.

Owing to the high dispersal capacity of golden jackals and the opportunistic nature of our data, it is not currently possible to estimate the number of distinct individuals in

Table 1 Verified records of golden jackal presence in Finland. Locations in Fig. 1

Date	Document	Number in Fig. 1	Surrounding environment
Aug. 5, 2018	Trail camera picture	1	House-yard
Jan. 16, 2019	Trail camera picture	2	Forest
July 23, 2019	Photo taken by camera	3	Roadside
From Nov. 22 2020 to Sept. 1, 2022	Trail camera pictures (Nov. 22 2020, Jan 8 2021, April 16 2022), probably a male based on its posture during urination	4	Forest, feeding station
March 1, 2022	Adult male found dead, captured in a fox-snare (Fig. 1), vocal records earlier in winter	5	Forest
March 27, 2022	Photos of tracks, vocal records in March 2022	6	Forest

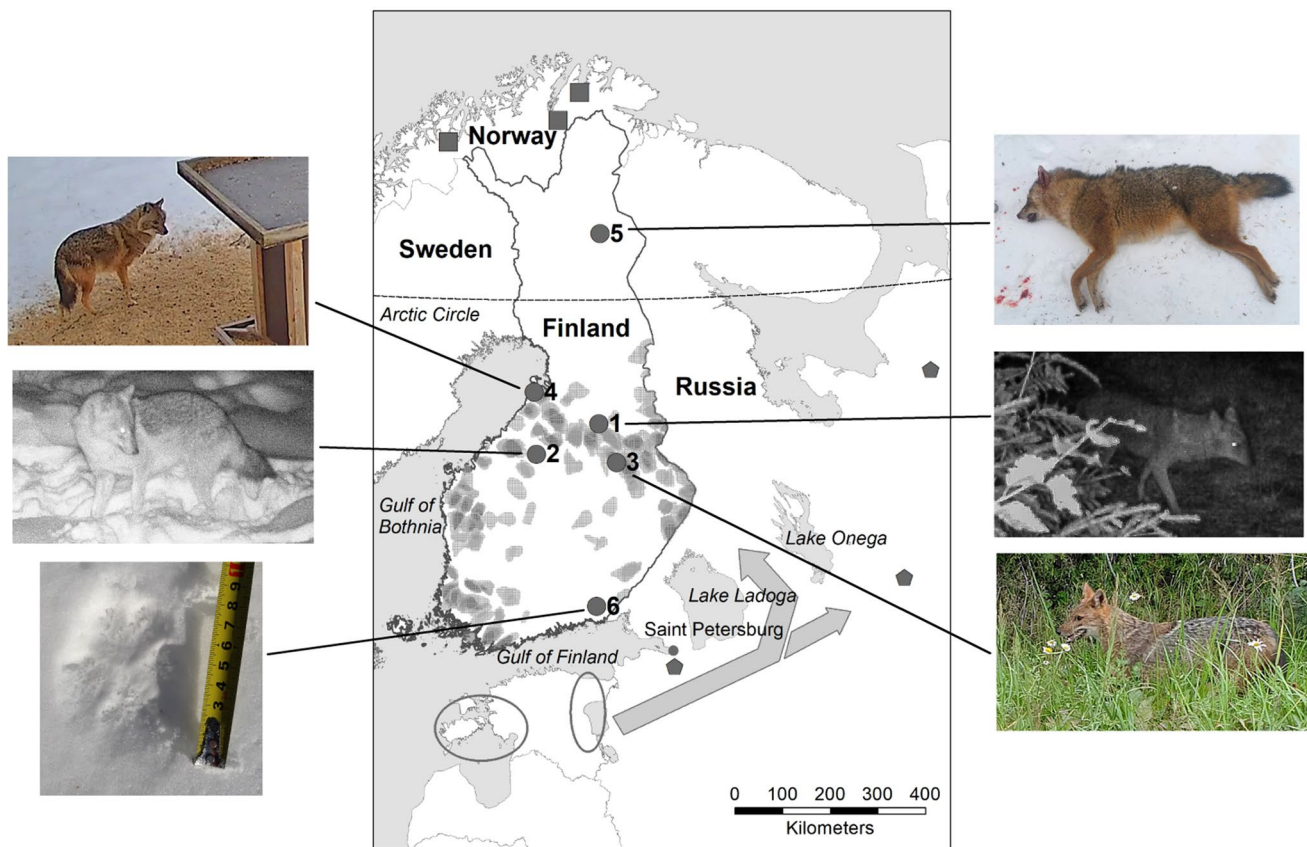


Fig. 1 Verified records of golden jackal presence in Finland (circles), Norway (squares) and northwestern Russia (hexagons) during 2018–2022 and potential movement routes (arrows) from Estonian jackal populations (ovaloid shapes) to Finland and North-Western Russia. Numbers associated to Finnish records refer to numbers in Table 1. Observations outside Finland were obtained from Sørensen

and Lindsø 2021 (Norway) and Rykov et al. 2022 (Russia). Photos: 1 by Tanja Nuotio, 2 by Hanna-Leena Paananen, 3 by Jarmo Korhonen, 4 by Tommi Lainas, 5 by Seppo Mutttilainen and 6 by Tiia Kimmo. Shaded areas show wolf territories in 2018–2022 (cf. Mäntyniemi et al. 2022)

Finland. There are thousands of trail cameras maintained in the country, primarily deployed by moose and deer hunters, but also many at baits used for shooting foxes (*Vulpes vulpes*) and raccoon dogs (*Nyctereutes procyonoides*); because golden jackals tend to use anthropogenic food source extensively (Lanzski et al. 2022), and probably even more so during the severe winter climate of Finland, it is likely that the detection probability is relatively high. In addition, we estimate that private owners of trail cameras are likely to report potential records of golden jackals in Finland since there is a general interest to monitor the species both for ecological reasons and potential conflict with human interests, and hunting and nature magazines have extensively published on the species colonization. Owing to the very large effort, albeit opportunistic in nature, we conclude that jackal occurrence is still rare in the country but that the trend is increasing, with even an indication of individuals settling (in at least two separate locations).

The most likely source of jackals observed in Finland is Estonia, where the species bred for the first time in 2012 and has gradually colonized the westernmost coastal areas of the country (Männil and Ranc 2022). The northern locations of Finnish observations might suggest that most jackals have moved into Finland via the isthmus located between the lakes Ladoga and Onega (Fig. 1), while the Megapolis of St. Petersburg may block the route through the isthmus between the Finnish Gulf and Lake Ladoga. If so, it could explain why most of the jackal observations are relatively north in Finland. The Russian observations from Arkhangelsk and Vologda regions (Rykov et al. 2022) tend to corroborate this scenario. However, given the species' high ecological flexibility, their arrival through the St. Petersburg Isthmus cannot entirely be ruled out. Although Estonia is the most likely origin of jackals recorded in Finland, Norway and Northwestern Russia, some long-distance dispersers could also potentially originate in Central Europe, or even in the Caucasus (Rykov et al. 2022). In Russia the golden jackal is present and breeding in southernmost segments of the country and

during the 2000s, four individuals have been killed in North-western Russia. In addition to jackals reported by Rykov et al. 2022 (Leningrad region 2007, Moscow region 2016, Archangelsk region 2021) and a newspaper article reports a jackal kill with an excellent photo at Belozersk in Vologda region, 400 km east of St. Petersburg in 2021 (personal communication with Alexei V. Abramov, Zoological Museum of St. Petersburg). However, our understanding of the status of golden jackals in Russia remains partial. In this context, obtaining data on the distribution of golden jackals in Russia is critical to understand and forecast future colonization of Finland.

Very little is known of golden jackal ecology in northern environments (Männil and Ranc 2022), and even less so in Finland. In such environments, it is likely that winter represents the most significant constrain for jackal survival. Observations in Finland indicate that one jackal has survived over two consecutive winters (record 4), and two others (5 and 6) possibly one winter. Information provided by local hunters, concerning the two northernmost individuals (records 4 and 5) indicates that these individuals have been highly dependent on anthropogenic food—regularly visiting feeding stations where oat was provided for roe deer in winter (record 4), and a location where local professional fishermen clean fish (record 5). Southern Finland is probably the most suitable habitat for golden jackals as the landscape is more heterogeneous, with a higher proportion of agricultural lands, and more diverse and abundant food sources—high small mammal density, abundant prey such as European hare (*Lepus europaeus*), roe deer (*Capreolus capreolus*) and white-tailed deer (*Odocoileus virginianus*), as well as a high density of mammalian and avian road kills. Cunze and Klimpel (2022) predicted that the changes in climate would create suitable environments for jackal west and north from its present distribution range but Finland was not regarded as a potential new area in their projections. Given observed spatiotemporal patterns in Central Europe (e.g., Slovenia), it can take several decades before sporadic occurrences lead to an actual population growth similar to what is observed in the species' core areas of southeastern Europe (Krofel et al. 2023).

In multiple countries, golden jackal presence seems affected by the occurrence of larger, dominant grey wolves (*Canis lupus*) (Krofel et al. 2017). In particular, the Balkan region experienced a rapid increase of golden jackal population following the decrease and fragmentation of historic wolf populations (Krofel et al. 2017). In Estonia, golden jackals seem to avoid regions which are inhabited by resident wolf packs (Männil and Ranc 2022). In Finland, only one record (record 4) was made in the periphery of a wolf breeding territory, while the five others are located outside wolf territory boundaries. So far no records of golden jackals have been reported from Southwestern

Finland, where food sources is certainly highest and snow cover duration shortest but which harbors the highest density of permanent wolf packs and territory-marking pairs of wolves in the country (Mäntyniemi et al. 2022). The spatial pattern of future occurrence of golden jackals may allow us to evaluate the influence of wolf on the species' colonization pattern in Finland. Future studies should evaluate how golden jackal will influence animal communities in Boreal environments. For example, jackals may locally influence the reproductive success of ground-nesting birds but also increase mortality of red fox and raccoon dog through intraguild competition and predation.

In Finland, the golden jackal is currently a fully protected species by the law of environmental protection. Whenever current expansion will lead to an increasing breeding population, the status of jackals might change into a game animal, which enables managers to approve licenses more readily for removal of damage-causing individuals. The examples from Estonia (Männil & Ranc 2022) and other European countries (Trouwborst et al. 2015; Hatlauf et al. 2021) indicate that jackal populations can sustain very high pressure. The benefits of such management in terms of jackal population regulation and human–jackal conflicts remain to be studied. Whenever models for potential harvest are based on reliable data on the size and demographics of the population, golden jackal populations can be successfully conserved when they have a legal status of a game animal.

Golden jackal dispersers are increasingly being recorded in Finland, especially in the central part of the country. In southern Fennoscandia, where the potential for future expansion and establishment of reproductive units is greatest, habitat fragmentation and geography (Baltic Sea, big lakes) may constrain dispersal routes. Thus far, all recorded jackals appear isolated and many are closely associated with anthropogenic food during winters. The ability for jackals to establish reproductive groups will condition the long-term potential of the species in Fennoscandia.

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Data availability Data are available from authors.

Declarations

Conflict of interest The authors declare no competing interests.

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