



# First documentation of golden jackal (*Canis aureus*) reproduction in Germany

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## Abstract

The golden jackal (*Canis aureus*), a mesocarnivore, is currently expanding from eastern towards western Europe. Reproduction of the species could be confirmed in several areas in central Europe in recent years. This study collects the first records of golden jackal reproduction in Germany in 2021 and 2022. A family group of at least five individuals could be confirmed using camera traps and scat surveys with a trained detection dog and subsequent genetic identification in 2021. In 2022, camera traps confirmed a second reproduction in the same area.

**Keywords** Breeding range expansion · Canidae · Central Europe

## Introduction

The golden jackal (*Canis aureus*) is a generalist mesocarnivore. Over the last decades, the species has expanded from its original core range in south-eastern Europe and colonized new areas across Europe (Hatlauf et al. 2021; Ranc et al. 2022). Germany is currently located on the western edge of the species' distribution range. Single individuals have been registered further west and north (France, the Netherlands, Norway) (Hatlauf et al. 2021; Linell et al. 2021); however, all known reproduction has been recorded east or south-east of Germany. Land use changes, climate change, and the absence of wolves, as well as combinations of these factors, could be drivers for the expansion of the jackal population in Europe (Spassov and Acosta-Pankov 2019).

The first evidence of a golden jackal in Germany was recorded in 1997 (Möckel and Podany 2015). Since then, single

individuals have been registered sporadically (Tillmann 2020). Since 2007, the number of evidences in Germany slowly started to increase. However, numbers have been constantly low and restricted to single individuals. No territorial animals were known before 2020, when first territorial behavior of single golden jackals could be confirmed (Böcker et al. 2020).

Based on a reported observation of more than one golden jackal in the area, our aim was to prove the presence of a pair or family group by camera trap recordings, trained dog searches, and related molecular genetic analysis.

## Material and methods

The territory of the golden jackal family group is located on a plateau in a low mountain range in southern Germany between the Black Forest mountains and the Swabian Alb mountains (districts Schwarzwald-Baar and Tuttlingen). It is encompassed by two adjacent nature reserves (IUCN management category IV). Access to the area is limited for humans. The area is characterized by a mosaic of different structures, such as bogs and reeds as well as an old open oak and pine forest. It is situated in the proximity of the river Danube. Other medium-sized and large mammals inhabiting the area are the red fox (*Vulpes vulpes*), Eurasian badger (*Meles meles*), raccoon (*Procyon lotor*), roe deer (*Capreolus capreolus*), fallow deer (*Dama dama*), and wild boar (*Sus scrofa*). There are neither wolves nor stray dogs or

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**Fig. 1** Camera trap picture from 26th October 2022, showing a juvenile golden jackal

other large carnivores known in the area and close surroundings. The area is located about 400–500 km from the closest known reproduction sites in Friuli-Venezia Giulia, Italy (Fabbri et al. 2014; Torretta et al. 2020; Bacci and Lunghi 2022). Other close reproduction sites are known in Milovice, Czech Republic (app. 525 km) (Jirků et al. 2018), in Neusiedl-Seewinkel National Park, Austria (app. 605 km) (Herzig-Straschil 2008; Hatlauf and Hackländer 2016) and in Kwidzyn, Poland (app. 965 km) (Kowalczyk et al. 2020).

All registered evidence was assessed and categorized referring to Hatlauf and Böcker 2022. To describe the following observations, only evidence with a C1 assessment was taken into account (camera trap pictures/videos and genetically confirmed scat). Different camera models were used (Cuddeback C-series IR, Bushnell CoreCam IR, and Reconyx Hyperfire 2 IR). The cameras were set to take pictures without delay, and a number of 3–5 pictures were taken for every registered movement. During some periods, single cameras were set on video recording. Events were distinguished from each other if there was

a time delay of > 60 s between pictures of one triggered series to the next. Since the first evidence in the study area from 2021, camera traps were used to detect jackal presence constantly. The four cameras were set up on an area with the size of approximately 20 hectares. The longest distance between two of the cameras was about 600 m.

Scat samples were analyzed at the Senckenberg Center for Wildlife Genetics. Following DNA extraction, an initial species determination was performed using the hypervariable domain of the mitochondrial control region (D-loop). In confirmed golden jackal samples, we amplified 13 unlinked autosomal microsatellite loci as well as two sex markers for individualization and sex determination. All genetic analysis was performed as described in Hatlauf et al. 2020.

## Results

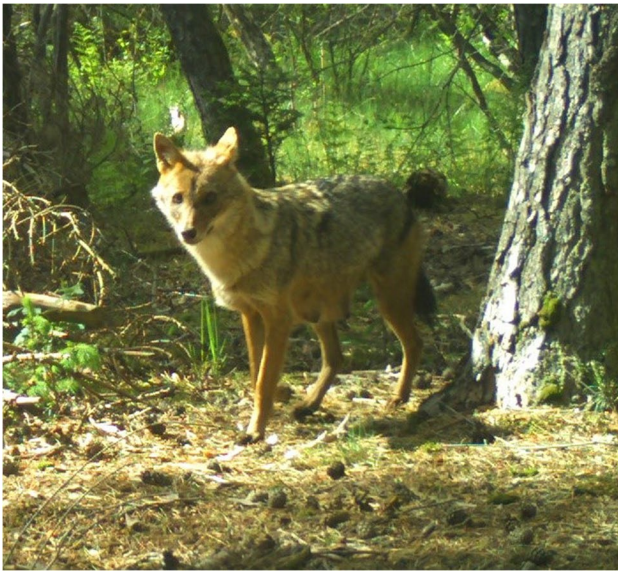
### First proof of reproduction 2021

The first evidence of golden jackal presence in the study area was given on October 1, 2021, when a photographer observed and photographed two golden jackals. Subsequently, we set up 4 camera traps in the area on October 19, 2021. Camera traps were controlled roughly every 6 weeks. The camera traps provided one event on October 26, 2022, which showed 2 golden jackals in one picture. One of those animals has a typical juvenile appearance (see Fig. 1). Concerning this appearance, the species' reproduction and dispersal biology as well as the distance to other known reproduction sites, it could be concluded that the juvenile was born in the area, and the picture was regarded first proof of a reproduction in the area. This could, later on, be confirmed by further genetic evidence, see Table 1. The camera traps recorded 16 C1-events of golden jackals in 2021 from 19<sup>th</sup> October to the end of the year. Three events showed two individuals while 13 events only recorded single golden jackals.

On three occasions, the study area was also searched with a trained scat detection dog (Hatlauf et al. 2020). A total of 8 scats were found. A total of 7 gave a result in genetic analysis and revealed 4 golden jackals which

**Table 1** Genetically identified golden jackal individuals and their proposed relationship

Date	Sample type	Individual confirmed	Relationship
19/10/21	Scat	GG014m	Sibling of GG015f, GG017f, GG018m
19/10/21	Scat	GG015f	Sibling of GG014m, GG017f, GG018m
01/11/21	Saliva	GG016m	Father of GG014m, GG015f, GG017f, GG018m
11/11/21	Scat	GG017f	Sibling of GG014m, GG015f, GG018m
16/12/21	Scat	GG018m	Sibling of GG014m, GG015f, GG017f



**Fig. 2** Lactating golden jackal female photographed by a camera trap on 21st May 2022

could genetically be identified as very likely siblings. The eighth scat revealed a raccoon.

Besides, saliva samples were taken on a sheep carcass found in the area on November 1, 2021. The carcass was documented on-site, and saliva samples were taken. A subsequent pathological examination could not determine the cause of death. There were no signs indicating that the sheep was killed by a golden jackal. The carcass did however show signs of intense scavenging. Saliva



**Fig. 3** Two adult golden jackals accompanied by a jackal cub on 20th June 2022

samples revealed a further individual (GG016m) which is assumed to be the father of the offspring.

Thus, a total of 5 individuals could be genetically identified. It is assumed that—if the mother was still alive—the family group consisted of at least 6 animals in autumn 2021.

### Second reproduction in 2022

Since the camera traps were set up in 2021, 90 camera events of golden jackals have been registered until August 2022 (count only C1-evidence). On May 21, 2022, a lactating female golden jackal was recorded (Fig. 2). On June 20, 2022, pictures show two adult golden jackals accompanied by a golden jackal cub (Fig. 3). On the following day, 2 adult golden jackals with four cubs were photographed. Camera trap pictures from August 2022 show four cubs ranging and resting together (Fig. 4). No genetic samples have been collected in 2022.

### Discussion

This report describes the first confirmed evidence of golden jackal reproduction in Germany. All known reproductions so far were located further south and east (Bacci and Lunghi 2022; Jirků et al. 2018; Hatlauf and Hackländer 2016; Kowalczyk et al. 2020). It is therefore assumed to be the westernmost known reproduction of the species.

We conclude that in 2022, two adult golden jackals, at least four cubs, and an unknown number of 1-year-old golden jackals lived in the study area. It is assumed that sub-adult individuals will migrate to adjacent areas. Small-scale monitoring is established for further investigation. It is planned to conduct further scat searches with trained dogs. Genetic identification of golden jackals can reveal more information about migrating behavior of the species in Central Europe if identified individuals are later on detected in other areas. Increased collaboration of genetic laboratories concerning this species could help to answer questions about the dispersal and migrating behavior of golden jackals in Europe. As golden jackals do not only appear in south-western Germany but in all other regions of Germany and neighboring countries, unnoticed territorial jackals and reproduction are likely. A focus on potential occurrence and good communication about this animal can help to get a better insight into the development of golden jackals in Europe.

**Fig. 4** Four jackal cubs resting in front of a camera trap on 27th August 2022 (picture 3 out of series of 5)



**Author contribution** Felix Böcker and Hannah Weber contributed to the study conception and design. Material preparation, data collection, and analysis were performed by them. Sebastian Collet did the analysis and interpretation of genetic samples and results. The first draft of the manuscript was written by Felix Böcker and Hannah Weber, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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**Data availability** Data are available at Forest Research Institute/Böcker & Weber (camera trapping and scat surveys) and Senckenberg Institute/Collet (genetics). Requests can be received by corresponding author.

## Declarations

**Conflict of interest** The authors have no competing interests to declare that are relevant to the content of this article.

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