



Northernmost record of reproduction of the expanding golden jackal population

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Abstract

Golden jackal (*Canis aureus*) is expanding north in Europe. So far, its reproduction has rarely been reported in the expansion area. In this paper, we describe the first cases of reproduction of golden jackal from northern Poland, 500 km north from previously reported records. In summer 2015 and 2017, golden jackal juveniles (four and five individuals, respectively) sightings were recorded near Kwidzyn in Vistula river valley, where jackals have been observed repeatedly since 2015. These are the northernmost records of golden jackal reproduction in Europe. Since 2015, golden jackal was recorded in 15 locations in different parts of Poland, usually in the vicinity of larger rivers in mosaic habitats. The reproduction records suggest local establishment of population with predicted population increase and further expansion. First observation and record of reproduction in the same year suggest that expansion of golden jackal in Poland took place earlier and was not recorded, probably due to lack of knowledge on the species and failure to recognize its individuals.

Keywords *Canis aureus* · Species distribution · Natural expansion

Range shift is one of the relatively well-understood responses of organisms to climate change (Williams and Blois 2018). It has evolved to maximize species fitness in a particular ecological niche and match their spatial shifts (MacArthur 1972; Sexton et al. 2009). The process of range shift includes four key stages: (1) emigration: individuals leave natal location; (2) movement: transfer of individuals away from original location; (3) establishment: the ability of individuals to reproduce and found new populations; and (4) proliferation: the growth of established populations to become more than self-sustaining and able to further spread (Estrada et al. 2016). Successful range shift and population establishment require similar or substitutable resources in the new environment, including food and shelter in the short

term, and mate availability in the long term (Šálek et al. 2014; Hovick et al. 2016; Mukherjee et al. 2018).

The golden jackal (*Canis aureus*) is one of the southern carnivore species, that after population decline and recovery, not only recolonized its previous range, but also is expanding in Europe (Arnold et al. 2012; Trouwborst et al. 2015; Kusza et al. 2019). In recent years, new records of golden jackal in Baltics, Belarus, Czech Republic, Germany, Poland, etc. were reported (Trouwborst et al. 2015; Kowalczyk et al. 2015; Grichik et al. 2018; Jirků et al. 2018). The population is probably in the movement stage as population establishment including reproduction is rarely reported (Pyšková et al. 2016; Jirků et al. 2018; Lanszki et al. 2018). Golden jackals may disperse rapidly and over long distances, even across human-dominated landscapes (Lanszki et al. 2018). In expanding populations, species occurrence and reproduction in new areas are probably observed and reported with some delay, related to the low probability of observation being a result of low densities at the beginning of colonisation, lack of knowledge on the species and the likelihood of confusion with other animals (McKelvey et al. 2008).

In this paper, we describe the first evidence of golden jackal reproduction in Poland, the northernmost ever found in Europe, based on repeated observations of juvenile

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individuals. We also update the occurrence records of golden jackal in Poland.

The observations of juvenile jackals were collected by experienced hunters and foresters during field visits and occasionally confirmed by photo-documentation. Other records of jackal presence from Poland were based on necropsy and morphological (including connate pads of the medial toes of fore and hind limbs) and genetic investigation of dead individuals conducted in the Mammal

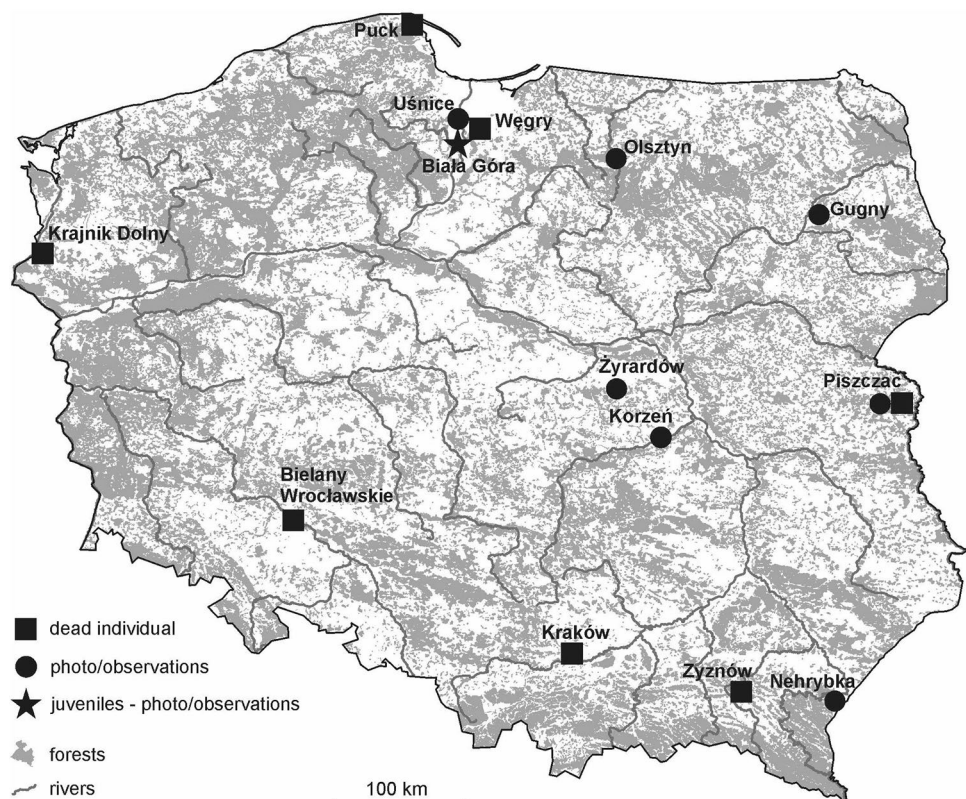
Research Institute, Polish Academy of Sciences (for details see Kowalczyk et al. 2015), or photographs and videos received. Jackals on photos and videos were identified on the basis of the features such as coat coloration, body size and proportions, and the tail length.

In late August 2015, a golden jackal family including 2 adults and 4 juveniles were observed at dusk on the fields near Biała Góra village in Kwidzyn area in N Poland (Table 1; Fig. 1). The same animals were seen several

Table 1 Observations of golden jackals in Kwidzyn area (N Poland)

Date	Location	No of jackals	Remarks
August 2015	N53.9221, E18.8880	2 ad + 4 juv	Observation by experienced hunter
Autumn 2015	N53.9282, E18.8965	2 ad + 3 juv	Observation and howling
December 2016	N53.8694, E18.9376	1 ad	Observation
30 December 2016	N53.9717, E18.9643	1 ad	Dead individual, probably killed by wolves, necropsied and genetically investigated in the Mammal Research Institute PAS
05 August 2017	N53.9628, E18.9103	5 juv	Juveniles photo-documented when emerging on the terrain road
31 July 2019	N53.9659, E18.9032	4–5 ?	Howling
10 August 2019	N53.9652, E18.9031	1 ad	Observation and howling
12 August 2019	N53.9652, E18.9031	2 ad	Observation and howling
29 August 2019	N53.9652, E18.9083	2 ad	Observation and howling

Fig. 1 Localisations of golden jackal records in Poland from 2015 until present. More information are given in Table 2



times by hunters and foresters in the area in late summer. In autumn 2015, 2 adults and 3 juveniles were observed and heard when howling. Single individuals were seen repeatedly during the next years. In August 2017, five juveniles were seen emerging on the terrain road (Table 1, Fig. 2). Between July 2015 and July 2019, 15 confirmed records of golden jackal in Poland were reported (Fig. 1 and Table 2). There were seven dead individuals (six genetically confirmed at MRI PAS) and eight observations (seven confirmed by photos or video). All the observed individuals or group members had size and coat coloration typical for the golden jackal. Majority of the observations were in the vicinity of larger river valleys, seashores or lakes in mosaic habitats including meadows, marshes, agriculture, waste and woodlands.

Since the first case of golden jackal presence in Poland in 2015, very limited number of observations or dead individuals had been recorded (Kowalczyk et al. 2015, this study). This indicates movement phase and exploration by migratory individuals rather than establishment of the population. However, first records of reproduction from the same year as the first observation of the species in Poland indicate earlier than reported expansion and local population establishment far to the north from its original distribution range. The delay in species expansion discovery is probably related to the lack of knowledge on the animal and failure to recognize individuals of this new species. Since the first observation of golden jackal, media in Poland reported almost every new record of the species. This led to the increasing number of species records reported by public; however, only very few cases turned out to be golden jackals. Majority of them were foxes, often suffering from scabies, dogs or wolves (R. Kowalczyk, personal comm). However, increasing knowledge on the species brings increasing number of confirmed observations. The scenario is similar to the expansion of raccoon dogs in Poland during the 1950s, when very fast spread and establishment of population was recorded, exceeding the biological capacity of the species (Nowak and Pielowski 1964; Kowalczyk et al. 2009; Kauhala



Fig. 2 Young golden jackal observed on 5th August 2017 in Kwidzyn area (N Poland) (photo by Piotr Żótkiewicz)

and Kowalczyk 2011). Thus, expansion and saturation of the environment were probably slower, and discovered with some delay, when growing abundance of the species and increasing knowledge allowed for more frequent species recording and rapid increase in the amount of data on species occurrence.

Despite several unconfirmed breeding records outside its continuous European range (Trouwborst et al. 2015), the northernmost reproduction of golden jackal so far was confirmed in northern Czech Republic (Jirků et al. 2018). Reproduction of golden jackals 500 km north from the previously reported location indicates fast expansion and local establishment of the population. In the Kwidzyn area, where the reproduction was recorded, repeated observations of single individuals and groups of jackals and howling were reported. Thus, local establishment of population and reproduction is associated with more frequent signs of animal presence and territorial behavior (howling).

The majority of observations of jackals in Poland are in lowlands, near river valleys and wetlands, which are typical habitats of golden jackal (Trbojević et al. 2018). River valleys may also play a role of migratory corridors facilitating expansion in human-dominated landscapes such as in Poland (Huck et al. 2010), offering abundant food resources during migration, for this vole-specialized carnivore (Lanszki and Heltai 2002; Penezić and Čirović 2015).

In 2017, golden jackal obtained in Poland the legal status of game species with the hunting season from 1st August to the end of February with delayed implementation until 2019 (Regulation of the Ministry of Environment, 1st August 2017). However, the low number of species records puts the hunting of jackals into question in the light of the status of golden jackal in European legislation (Trouwborst et al. 2015; Sillero-Zubiri et al. 2004). Golden jackal is listed in Habitats Directive Annex V (Council Directive 92/43/EEC of 21 May 1992), which covers animal species of community interest whose exploitation may be subject to management measures; however, according to the Directive provisions, it should also be maintained at favorable conservation status. It rather indicates need of species protection, not hunting, at the present state in Poland. It also carries a risk for widely distributed and increasing population of wolf, protected in Poland, with which the golden jackal may be confused.

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Table 2 A list of confirmed records of golden jackal in Poland (see also Fig. 1)

No.	Location	Coordinates	Date	Sex	N indiv.	Reproductive status	Description	Source
1	Krajnik Dolny	N53.0616, E14.3619	13.04.2015	Male	1	–	Road kill	Kowalczyk et al. (2015)
2	Gugny	N53.3476, E22.5973	01.05.2015	?	1	–	Photo	Kowalczyk et al. (2015)
3	Piszczac	N51.9480, E23.3950	10.06.2017	?	1	–	Photo	Kowalczyk et al. 2015
4	Nehrybka	N49.7442, E22.7996	13.07.2015	?	1	–	Photo	This study
5	Biała Góra	N53.9221, E18.8880	08.2015	?	6	–	Observation	This study
6	Piszczac	N51.9491, E23.3841	09.09.2015	Female	1	? ^a	Road kill	This study
7	Węgry	N53.9717, E18.9643	30.12.2016	Male	1	–	Dead animal	This study
8	Olsztyn	N53.7633, E20.4686	29.03.2017	?	1	–	Photo	This study
9	Uśnice	N53.9628, E18.9103	05.08.2017	?	5 juv	–	Photo	This study
10	Żyrardów	N52.0598, E20.4710	30.04.2018	?	1	–	Video	This study
11	Puck	N54.7555, E18.3905	21.09.2017	Female	1	Non breeding	Road kill	This study
12	Kraków	N50.0870, E19.9886	31.03.2019	Male	1	–	Road kill	This study
13	Zywnów	N49.8170, E21.819092	02.04.2019	Male	1	–	Shot	This study
14	Korzeń, Central Poland	N51.6401, E20.8938	15.07.2019	?	1	–	Video	This study
15	Bielany Wrocławskie	N51.0339, E16.9858	12.2017	Male	1	–	Shot and stuffed	This study

^aNot possible to determine due to carcass decomposition

Compliance with ethical standards

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

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