



First record of allonursing in golden jackal (*Canis aureus*, L. 1758): a case of double breeding and communal denning within the same social unit

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Abstract

In the last decade, there has been a remarkable increase in the number of scientific publications on the ecology of the golden jackal *Canis aureus*, whereas information on its reproductive biology is still scanty, and the basic reproductive parameters of the species are not yet fully understood. In 2021, we began a research project in North-Eastern Italy, where the golden jackal is strictly protected under the National Law, to investigate the species behavioural ecology and reproductive biology at the den site, as a key element for defining conservation measures. Within this project, we documented allosuckling behaviour, possibly related to the breeding of two females within the same social unit, with den sharing and communal nursing of the cubs. Our observations open new scenarios and raise questions on the reproductive biology and social organisation of the golden jackal, stimulating further topics for research.

Keywords Allonursing · *Canis aureus* · Reproduction · Social behaviour · Communal denning

Introduction

In the last 10 years, there has been a considerable increase in the number of scientific publications on the golden jackal *Canis aureus*, e.g. on its genetics (Fabbri et al. 2014; Galov

et al. 2015; Stronen et al. 2021), biogeography (Arnold et al. 2012; Trouwborst et al. 2015; Spassov and Acosta-Pankov 2019; Lanszki et al. 2022; Cunze and Klimpel 2022), habitat selection (Šálek et al. 2014; Torretta et al. 2020; Selimovic et al. 2021) and trophic ecology (Ćirović et al. 2014, 2016; Lanszki et al. 2015, 2016, 2018; Lange et al. 2021). Conversely, there is still a lack of information on its behavioural ecology and reproductive biology, as most of the relevant literature actually refers to the African wolf *Canis lupaster* (e.g. Jhala and Moehlman 2004; Moehlman and Jhala 2013; Moehlman and Hayssen 2018), a medium-sized canid occurring on the African continent, which was regarded as a conspecific of *Canis aureus* before being classified as a separate species (Viranta et al. 2017; Krofel et al. 2021). In particular, little is actually known on the reproduction and social behaviour of the golden jackal within its European range, where this canid is locally subject to lethal control or hunting, as a species listed in EU Habitats Directive 92/73/EEC, Annex V (Hatlauf et al. 2021). Accordingly, following Article 14 of the same Directive, a species can be hunted/controlled as long as a Favourable Conservation Status is maintained (i.e. also when listed in the Annex V). However, management plans are often devised without actual data on local density, at official rates overpassing 90–100% of the estimated population (i.e. Romania), while there is a lack of knowledge on the species adaptability to intensive hunting,

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given that the basic reproductive parameters are not yet fully understood. A good knowledge of the reproductive biology of a species is pivotal to elaborate appropriate conservation or management strategies (Lucena Perez et al. 2018; Comizzoli and Holt 2019). In this context, studies at den sites represent a key element for improving such knowledge (e.g. Nakazono and Ono 1987; Kowalczyk et al. 2003; Mori et al. 2016; Cunningham et al. 2022). For this reason, in 2021 we began a research project in north-eastern Italy, to investigate the behavioural ecology and reproductive biology of the golden jackal at the den site.

Since the golden jackal in Italy is not subject to hunting or control measures, being strictly protected under the National Law, this country is ideal to study the species behavioural and population dynamics. In fact, hunting may alter population dynamics in different ways, also by affecting behaviour and reproductive strategies (Milner et al. 2007; Loveridge et al. 2007; Wielgus et al. 2013; Gosselin et al. 2015; Van de Walle et al. 2021). In this note, we report the first evidence of allonursing in the golden jackal. We also discuss various reproductive scenarios to explain the presence of cubs at different stages of growth observed in the same den, concluding that two females reproduced within the same social unit.

Materials and methods

Our study area is located in north-eastern Italy, in the continental bio-geographic region, and encompasses the lower stretch of the Isonzo river catchment, including the lower reaches of Torre stream (a tributary of the Isonzo). Amongst the factors affecting golden jackal occurrence (e.g. Ranc et al. 2017), the study area includes the following: (i) high human population density; (ii) proximity to rivers and streams; (iii) local absence of grey wolf *Canis lupus* packs; and (iv) short/absent snow cover persistence. The study area includes the Natural Reserve “Foce dell’Isonzo”, a protected area located along the final stretch of the river, which corresponds broadly to the SAC/SPA IT3330005 “Foce dell’Isonzo—Isola della Cona”. First, we estimated the jackal density in the study area through a preliminary survey, combining the bio-acoustic monitoring method (Giannatos 2004) and the reproductive group occurrence with opportunistic camera trapping. To locate groups unresponsive to acoustic stimulation, we searched for *rendezvous* areas and we used opportunistic camera trapping (trapping effort = 90 camera trap-days) to confirm the presence of juveniles in August–September. The criteria used to identify different social units in the study area were (a) distance between *rendezvous* locations; (b) time overlaps of the camera traps records; and (c) the occurrences of an adult male fitted with a GPS-telemetry collar (by another research group not involved in this study). Afterwards, during 2021

and 2022 breeding seasons, using 1–3 IR sensor cameras per site (different models with LEDs of $\lambda = 940$ nm), we investigated a total of 24 setts/earths within the study area, selecting those considered potentially suitable for the golden jackal (mainly secondary or abandoned burrows dug by the European badger *Meles meles*). Controls of camera traps were carried out by one operator alone, in order to replace memory cards and batteries when needed. During the controls, the utmost care was taken to minimise disturbance. At the site where allonursing occurred, one camera trap (model = Browning BTC-8A Spec Ops Advantage) was active from 20/02/2022 to 30/06/2022. This camera trap was pointed at the only entrance of the den, and programmed to be active 24 h a day and to record 30-s-long videos for each trigger event. Overall, the trapping effort at this site was 130 camera trap-days. Eighteen out of 130 camera trap days were lost because of camera trap failures that occurred between 29/04 and 24/05, caused by the memory card saturation. All videos collected at this site were watched separately by three of the authors (S.P., M.D.L. and O.B.) to assess and interpret the observations.

Results and discussion

Five jackal groups were detected in the study area with the combined method during our preliminary survey, corresponding to a local density of 0.53–0.65 groups/10 km². Jackals were recorded by camera traps in 12 burrow sites through the 2021–2022 monitoring programme. Two of these sites were occupied by different reproductive groups of golden jackals during the breeding season: (i) in 2021, a burrow located in the floodplains of Torre stream was occupied by a breeding pair with three cubs for at least 58 days (07 April–04 June); (ii) in 2022, a burrow located in the floodplains of the Isonzo river (inside the protected area included in the Natural Reserve “Foce dell’Isonzo”) was occupied by a group with cubs for 49 days (09 April–28 May). This last group included three adults: a breeding pair and a subordinate female with the role of helper. We collected a total of 1814 videos of this group during the den occupation, corresponding to 15 h and 12 min of footage. In Table 1 are reported in chronological order the most relevant records related to reproduction and nursing inside this group. Allosuckling by the helper female was recorded multiple times between 02/05 and 25/05. The two females were recorded interacting peacefully throughout the den occupation, also suckling the cubs simultaneously.

Beside allosuckling, the most intriguing aspect of our observations is that, for a short period, cubs at two distinct stages of growth were recorded at the same time in a single den, suggesting the presence of 2 L born in different periods (i.e. early April and May). However, without supporting

Table 1 Relevant records related to reproduction and nursing inside the monitored group

Date	Observations
04/04	Last record of the dominant female pregnant
09/04	Burrow occupation: the dominant female brings inside the burrow eight newborn cubs (born elsewhere between 04/04 and 09/04)
10/04	The subordinate female is recorded in the site for the first time, while she enters inside the active den with the dominant female
26/04	First independent exit from the den of one cub
02/05	The subordinate female is recorded allo-suckling some of the cubs for the first time
09/05	Eight cubs of the same size are recorded together outside the den for the first time
19/05	The two females are recorded suckling the cubs together
20/05	The cubs are recorded eating solid food for the first time
20/05	The dominant female brings out of the den three helpless cubs never observed before. Shortly after, these cubs are brought back inside the den by the subordinate. Later on the day, the dominant female moves away a total of four helpless cubs (putative newborns)
21/05	The subordinate female brings at least one of the helpless cubs back to the den
24/05	Last record of one of the four putative newborns
25/05	Last record of the eight bigger cubs together, while the subordinate female is suckling them
28/05	Jackals leave the den: last record of some of the bigger cubs

molecular analyses, this possibility has to be carefully assessed. Therefore, we have considered four reproductive scenarios, i.e. (i) 1 L of 12 cubs with different growth stages associated with pseudopregnancy of the subordinate female, (ii) polyandry of the dominant female and pseudopregnancy of the subordinate female, (iii) polygyny and (iv) breeding of the subordinate female with a male different from the local dominant male. Although canids societies are mostly based on monogamy (Macdonald et al. 2004), some cases of polygyny, polyandry, polygynandry, plural breeding, communal breeding, cooperative breeding and promiscuity exist (Macdonald et al. 2019). We were unable to find any references to these topics in the golden jackal literature. Cubs of the same litter may have different growth rates depending on the nourishment received in the first weeks of life, resulting in differences in the development (e.g. Millar 1977; Western 1979). It is also known in several mammalian species that females can lactate without be mated. However, we excluded the possibility of 1 L, mostly because of the clear difference in the development stage. Accordingly, in the last 10 days of May, there were eight cubs undergoing weaning ranging widely around the den and, at the same time, four cubs still unable to walk, and covered by the dark-brown fur which is characteristic of newborn jackals (Supplementary Material 1). In addition, the size differed widely (~ 1:6 based on visual comparison). Such differences appear too wide for 1 L. Moreover, a litter of 12 cubs would be exceptional, as the maximum number of placental scars observed in female jackals is nine (Vlasseva et al. 2020). To conclude, on 4th of April the dominant female brought inside the den only eight newborn cubs, which is consistent with the following observations: the first independent exit from the den of one cub was on 26th of April and on 9th of May eight cubs of the same size were recorded together outside the den for

the first time, while the first record of the four smaller cubs was on 20th of May (see Table 1). Polyandry is known in canids, despite information on this behaviour is still scanty. In an urban area of the UK, female red foxes *Vulpes vulpes* were mated by more than one male during estrous, giving birth to litters with multiple paternity (Baker et al. 2004). Polyandry has been also reported in other canids, e.g. the African wild dog *Lycaon pictus* (Girman et al. 1997; Spiering et al. 2010) and the Island fox *Urocyon littoralis* (Roemer et al. 2001). This option can be easily discarded, since multiple paternity is not related to size and development variability between cubs in any publication we consulted. Moreover, the golden jackal seems to have a higher degree of monogamy than the red fox based on the gonadosomatic index (Vlasseva et al. 2020). Hence, reproduction of two females looks as the most fitting scenario, stimulating questions on the paternity of the litters. Amongst Canids, cases of polygyny have been reported in wolves (Mech and Nelson 1989), red foxes (Zabel and Taggart 1989; Baker et al. 2004), swift foxes *Vulpes velox* (Kamler et al. 2004; Kitchen et al. 2006), and bat-eared foxes *Otocyon megalotis* (Pauw 2000). However, while the dominant female cooperated harmoniously with both the male and the subordinate female to rear the cubs through the denning period, aggressive behaviours (e.g. threatening displays, biting) by the male toward the subordinate female occurred at almost each of their encounters, particularly in the first period of den occupation. Based on these observations, polygyny also appears to be an unlikely interpretation. In conclusion, we argue that the subordinate female may have mated with a male extraneous to the social group before uniting with the territorial pair and giving birth to a second litter. This option may also explain the mildly aggressive behaviour shown by the resident male toward the subordinate female. Nonetheless,

the dominant male may have behaved differently towards the subordinate female during her estrous, therefore bigamy cannot be totally excluded. Camera trap failure occurred during the den occupation (in the period 29/04–24/05) and may have affected the collection of important events, e.g. displacement of the younger cubs. Apparently, these cubs perished in the first phase of life, not being recorded leaving the den, while the other members of the group (including the subordinate female) were observed in the area surrounding the den during June. The corpses of the cubs from the putative second litter were not retrieved and analysed to determine the cause of death. Allonursing has been observed in several canids (Macdonald et al. 2019) and reported in all *Canis* species except golden jackal (Lord et al. 2013), before our work. In 2022, we monitored at the den site a group of jackals composed by a breeding pair, one subordinate female with the role of helper and a total of 12 cubs. Allosuckling by the subordinate female was observed multiple times during the den occupation. The simultaneous presence in the site of cubs at two distinct stages of growth suggests that both females of the group reproduced, giving birth in different periods (i.e. early April and May). Amongst Canids, cases of communal denning have been reported in wolves (Mech 1970; Packard 2003), swift foxes (Kamler et al. 2004), coyotes *Canis latrans* (Gier 1975; Hennessy 2007), black-backed jackals *Lupulella mesomelas* (Ferguson et al. 1983) and in Arctic foxes *Vulpes lagopus* (Norén et al. 2012), but they have never been reported for golden jackals. More precisely, in this case, the dominant female gave birth to eight cubs in the first days of April in an unknown site, before moving the litter into the monitored burrow. In late May, a second litter of four newborn cubs was present in the same den, as the likely result of whelping by the subordinate female occurred afterwards. The paternity of the 2 L is unclear, but the social tension between the resident male and the subordinate female suggests that these litters may have different sires. The two females cooperated in nursing the first litter, whereas, apparently, the second litter did not survive for unknown causes. Communally raising litters may allow one mother to remain at the den while the father and the second mother forage and provision food for the cubs, thus improving reproductive success of both females. This behaviour may also increase den defence, as well as reducing the amount of time each female needs to stay away from the den, and its exposure to threats. Since genetic material was not collected during our study, the kinship between the dominant female and the helper is unknown. However, in canids societies additional group members tend to be offspring of the breeding pair (Way et al. 2010; Stenglein et al. 2011). Thus, any reproductive female allowing her offspring to reproduce within her range also increases her final fitness (e.g. Cameron et al. 2011). Our observations open new scenarios and raise questions on

the reproductive biology of *Canis aureus*, stimulating further research topics. The ongoing monitoring on the golden jackal den sites should continue in order to deeply investigate the organisation of social units, with special regard to the role of subordinate animals. Further molecular studies are necessary to support our observation and to exclude any other possibility apart from the one we discussed in this work.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10344-023-01671-5>.

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Author contribution S.P., E.M., F.F. and M.D.L. planned and supervised the study. S.P., M.D.L., S.C. and M.C. collected records. S.P., M.D.L., A.V. and O.B. watched the video material and interpreted observations. S.P. wrote the first draft. All authors participated in writing up all drafts.

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Data availability All data used in this note are available in the main text.

Declarations

Ethics approval and consent to participate None of the procedures performed in this study involved animal handling and were in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of interest The authors declare no competing interests.

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