



First occurrence of a reproductive group of golden jackal (*Canis aureus moreoticus*) in a densely populated area south of the Po River (Italy)

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Abstract

Although the presence of the golden jackal (*Canis aureus moreoticus*) in Italy has been documented since 1984, it has long been considered an accidental species confined to a limited portion of the northeastern sector of the country. Recently, dispersing individuals of golden jackal have been reported in different areas of northern Italy, suggesting an enhanced spreading attitude compared to the past. However, despite a wider covered area, no evidence of reproductive groups south of the Po River has ever been documented, suggesting possible geographical limitations due to the habitat or ecological conditions. This study witnesses the overcoming of this large freshwater course by the species, and describes the first reproductive group of golden jackals south of Po River in a context of a highly industrialized area. The results are obtained using different methods (citizen science, howling, camera trapping, search of signs) able to demonstrate an expansion of this mesocarnivore outside its traditional northeastern Italian distribution range. Interesting questions are also raised about the species ecology with special regard to its southern migration pattern through anthropic zones.

Keywords Canidae · Synanthropic fauna · Acoustic survey · Camera trapping · Ecosystem service · Citizen science

Introduction

Populations of Apennine carnivores are experiencing a quite pronounced recovery thanks to the introduction of protection laws banning uncontrolled hunting (Rondinini and Boitani 2007), the large availability of preys associated to the reconstitution of natural habitats, and the presence of ecological corridors after human depopulation of mountain

areas (Ercole et al. 2021). Despite this, the rich biodiversity inhabiting the Italian peninsula is still experiencing an unsteady equilibrium, mainly due to the fragmentation of habitats, introduction of invasive alien species and the over-exploitation of the natural capital (Ercole et al. 2021). This is particularly true for the northern sector of the country which alternates highly urbanized and polluted areas to more preserved natural ones within protected areas. Poaching, habitat exploitation and pollution pose most animal species under serious threats of local extinctions, despite their recent demographic increase (Ercole et al. 2021).

Among carnivores, the golden jackal (*Canis aureus moreoticus*) is nowadays experiencing a phase of great expansion all over Europe. Originally starting from three core areas, eastern Caucasus, eastern Transcaucasia, and the Dalmatian coast (Kryštufek et al. 1997; Spassov and Acosta-Pankov 2019), the species is nowadays present in more than 30 European countries (Hatlauf et al. 2021). Recently discovered reproductive groups are present in Germany (Böcker et al. 2023) and Poland (Kowalczyk et al. 2020). This impressive expansion has different origins, among them one is surely the decimation of the European wolf (*Canis lupus*), which has long been the principal competitor of the golden jackal in the wild during

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the last 150 years (Trouwborst et al. 2015; Krofel et al. 2017). Possible additional factors include abundant and easily accessible anthropogenic food resources, depopulation of rural areas, wildlife management, and climate changes (Fabbri et al. 2014; Šálek et al. 2014; Krofel et al. 2017).

Its arrival in northeastern Italy and its demographic spreading is intriguing conservation biologists and opens new perspectives concerning its ecological role in densely populated areas. Compared to the rapid expansion across Europe, colonization of Italy proceeds slowly. In fact, the first occurrence of reproduction was dated 1984 (Lapini and Perco 1989), but during the subsequent 35 years the species remained stable in northeastern Italy without further expansion, with separate family groups limited to this area (Lapini et al. 2018; Torretta et al. 2020). Presently, the golden jackal is patchily distributed in northern Italy where reproduction has been documented only in Friuli-Venezia Giulia and Veneto regions, while single dispersing individuals were sporadically observed in an area delimited by the Alps, the northern Po Plain, and the Apennines (Pecorella 2021; Bacci and Lunghi 2022). A general map displaying the current large-scale distribution range of this meso-carnivore in Italy has recently been published by Lapini (2022).

Approximately 150–190 specimens have been so far estimated in Italy (Franchini et al. 2019), but their scattered localization exposes them to high stochastic risk of local extinction as a consequence of human-wildlife conflicts (HWC) and the cohabitation with wolves (Lapini et al. 2018; Frangini et al. 2022).

Following the above cited natural history of the species in Italy, the aim of this paper is presenting data about the first finding of a reproductive golden jackal group south of the Po River, which is the major Italian water basin. Although rivers act as ecological corridors, and GPS collar tracking and bioacoustic stimulation have demonstrated that they do not represent impenetrable barriers (Selimovic et al. 2021), the role of the major Italian river settled along a densely populated and industrial area has long been debated. Therefore, the first description of a reproductive group in the southern sector of the Po Plain adds new data on the dispersal capacity of this species between northern and central Italy. In addition, this is an original story that starts from the occasional observation of a canid erroneously attributed to an Apennine wolf inside a parking lot during the strict Italian 2020 Covid lock-down. This “citizen science” encounter gave rise to an interesting research performed through an approach based on different methods able to highlight the southern migration of this new wildlife species.

Study area

The study area is located in Emilia-Romagna, northern Italy about 300 km from the closest previously confirmed reproduction site of the golden jackals in Friuli-Venezia

Giulia (Torretta et al. 2020). It is a highly anthropized area, about 3 km from the boundaries of the city of Parma, characterized by an industrial hub with a large food factory and an intensively cultivated land. The area is crossed by the Po River (total length 651.8 Kms, average flow rate 1,506 m³/sec, width within study area 165–310 m at regular flow) and tributaries Parma-Enza.

Despite a large human population, stray dogs are very rare, while foxes (*Vulpes vulpes*) and Italian Apennine wolves (*Canis lupus italicus*) are present together with additional meso and micromammalian species. The number of wolves in the Po Plain has been rapidly increasing lately, with an estimated density of 9.6 wolves/100 km² in the province of Parma (Aragno et al. 2022). Different wolf packs have already been identified in the surroundings and inside the investigated area, however the exact number of interacting wolves cannot be determined since the home-range of the considered jackals is not known at the moment. It must be remarked that the area submitted to bioacoustics survey was much larger and extending over different provinces. The area herein described is the one concerning the complete multi-technical approach and represents a subsection of the one initially submitted to jackal howling.

According to Köppen-Geiger climate classification, the reproduction site has a *Cfa* climate within a continental ecoregion.

Materials and methods

A multi-technical approach based on citizens' reports, jackal howling, camera trapping, and search of signs allowed data collection of golden jackal presence over a three-year period. Based on an initial citizens reports (Supplementary material), 26 jackal-howling emission sessions were performed northeast of Parma (about 109-km² area) during January, November and December 2021, and January, February, July, August and September 2022. Bio-acoustic methods have been applied using the standard GOJAGE stimulus and procedure (Hatlauf et al. 2016).

Following jackal howling positive results, camera trapping activity was carried out from June 2021 to September 2022 (Supplementary material). Four different cameras were used: one Boskon BG526, two Moultrie A-30i, and one Coolife 28MP. They were placed in 14 different sites chosen with opportunistic criteria, and set to take 20-s videos activated by infrared sensors. Camera traps were positioned 729 days with an average coverage of 52.07 days/site.

Study area was searched for presence signs such as feces, predation remains, and paw prints along 78 transects covering a total distance of 131.502 km and a surface of 137.770 square kilometers, from April 2021 to February 2022. Although

signs were occasional and somewhat not specific, they were connected to citizens sightings and road kills. All signs were validated by an expert-judgement before approval.

Results

The data collection carried out using different methods led to several evidences, supporting the hypothesis of at least one stable family group near the city of Parma. Jackal howling, camera-trapping, and citizens' reports gave positive results that are detailed in Table 1. Transects ($n=78$) in an area mainly covered by pastures and shrubs, which has been selected considering the work by Selimovic et al. (2021), revealed 3 supposed jackal paw traces and 22 potential jackal feces. Necroscopy was carried out on three young individuals (2 females and 1 male) following road kills and they were found in good health.

Three cubs were finally directly photographed within a rendezvous site in July 2023.

Discussion

This is the first ascertained presence of a reproductive group of golden jackals south of the Po river. Previously published data reported only scattered records (Lapini et al. 2018) and

no indication of reproductive activity has ever been recorded before this study. The report of two younglings and a pregnant female in 2021 and road kills of one young female and two younglings in 2022 are solid evidences that a reproductive group is living close to the northeast boundaries of the city of Parma, at least since the first "citizen science" report dated December 2020. A map illustrating the localization sites corresponding to the different observations is reported in Fig. 1.

This discovery of pregnant females (Figure in Supplementary material) and cubs (Fig. 2) constitutes a turning point for the hypothesis of a rapid complete colonization of the peninsular Italy by golden jackal, opening concrete possibilities to its expansion towards the less anthropized central and southern Italy, where vagrant individuals have recently been reported (Bacci and Lunghi 2022). On the other hand, previous extended monitoring in a vast area western of the original reproductive sites of north-eastern Italy, did not give positive results before our research.

It is noteworthy observing that despite the high adaptability of the golden jackal, little is known about its ecology in a densely urbanized area. Preliminary observation indicates scavenger-microtheriofagous habits of this mesocarnivore around farms, in agreement with current knowledge on golden jackals foraging behavior (Boskovic et al. 2013; Negi 2014), but its interaction with large urbanized areas, husbandry and industrial districts has to be fully investigated. In relation to

Table 1 Results of the multi-technical monitoring of golden jackals in the study area

2020		
December	Citizens' report	Video recording of a male Video recording of a pair composed by a female and a youngling
2021		
January	Jackal howling Camera trapping	Positive responses from a group Video with pair marking the area Single individual hunting in a dunghill (Supplementary material)
April	Camera trapping	4-individuals, group composed by a male, a pregnant female, and two younglings
July	Citizens' report	Photo of a dispersing individual
2022		
January	Road kill Camera trapping	Less than 1-year-old female Group composed by three individuals
February	Camera trapping	Video of a pair
March	Camera trapping	Video with pregnant female
April	Camera trapping	Video of pregnant female (photo in Supplementary material) with a youngling
June	Jackal howling	Family group with puppies
July		
September	Road kill	6-months-old female 6-months-old male
2023		
January	Citizens' report	Video recording of a pair composed by two adults
July	Citizens' report	Photo of three cubs inside a weaning (rendezvous) site (Fig. 2)

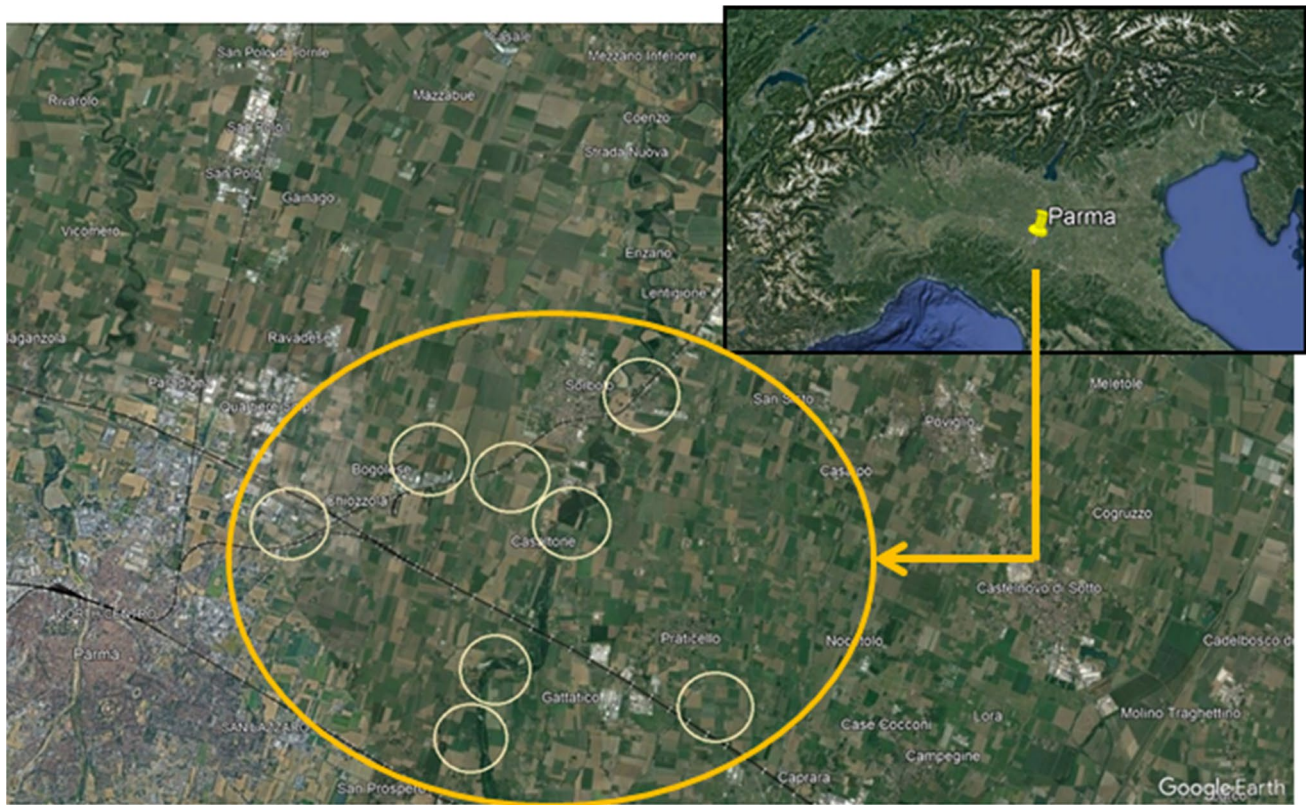


Fig. 1 Graphical illustration of golden jackals localizations nearby the city of Parma



Fig. 2 Evidence of successful reproduction witnessed by a cub emerging from the rendezvous site, July 2023. Copyright Diego Barbacini

this, the dispersal strategies, the family structure and the covered home-range in this plain area are not yet known.

Potentially, it could even have an important ecological role considering its scavenging capacity on wastes and the predatory habit on invasive pests (Ćirović et al. 2016). For this reason, the discovery of reproductive settlements in highly industrialized areas such as the lower Po Plain

becomes of fundamental importance and widens the discussion over human-wildlife conflicts in this densely populated region. In fact, although wild canids are generally proposed as pests by common people, their role as ecosystem services functional to the removal of highly impacting invasive micro and meso-mammalians should be fully considered (Stefanovic et al. 2024).

From this point of view, the number of Italian wolves in the Apennines piedmont and the Po Plain is also rapidly increasing, with an estimated density of 9.6 wolves/100 km² in the province including the study area of this work (Aragno et al. 2022). More precisely, at least two packs (but could be more) have already been identified living in the northern nearby of Parma. Wolf presence and concomitant expansion could be a constraint for the growth of golden jackals populations and could push it towards the occupation of the city suburban areas. In fact, there are data stating that the European wolf can outcompete the golden jackal (Krofel et al. 2017). This is an interesting topic for further investigations also considering that the home-range of this jackal group is still unknown. It is interesting to observe that historically the higher number of both reproductive Italian groups and dispersing specimens were concentrated in Friuli-Venezia Giulia, which has long been the region with the lowest number of wolves, to date about 20–25 specimens, divided in 2–4

packs, that have returned to this region only in recent times (Lapini et al. 2013). However, the Italian wolf is smaller and lives in small groups compared to its European counterpart and might not exert the same effect on golden jackal in Italy (Nowak and Federoff 2002; Ciucci and Boitani 2003).

All these aspects must be considered whenever questions arise on the jackals expansion strategies and habit use. Interestingly, the species has been limited to a narrow Italian area for decades and the recent rapid expansion seems quite unexplainable. Of course, many jackal-related phenomena are still unknown in Italy, and particularly in the study area, but recent studies confirm this species expansion as one of the fastest among European mammals (Stefanovic et al. 2024). Similarly to the raccoon rapid expansion in certain European areas, multiple causes could be addressed (Salgado 2018), starting from the great adaptability of the golden jackal to new environments and the ability to exploit a wide range of resources (Stefanovic et al. 2024).

From this point of view, the expansion of this recently discovered species in central Italy, settling with reproductive groups outside the original eastern entrance site, confirms the constant recovery of the mammalian fauna in Italy, and opens new perspectives on the ecology of *C. aureus*. In fact, evidence is emerging for the possibility of multiple groups already settled in the area which undoubtedly represents a highly productive ecosystem, able to sustain a wide carnivores population. More actions are therefore necessary to consolidate our knowledge on golden jackal presence in the Apennines piedmont, with special attention dedicated to the definition of family structures within a specific home-range, also considering its interaction with the consistent expansion of the grey wolf within a complicated highly anthropic urban system.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s13364-024-00745-2>.

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Author contribution All authors contributed to the study conception and design. Data collection and analysis were performed by EF, GB, LL, PLF, TT. The first draft of the manuscript was written by TT and revised by FNM, PV and LF. Final revision was performed by FNM. All authors read and approved the final manuscript.

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Data availability GPS coordinates of the rendezvous site (weaning homesite) and sightings were obtained and are available on request for scientific purposes.

Declarations

Ethical conduct The authors declare that the welfare of wild animals was preserved. All activities were carried out with special concern to avoid any harm or disturb to the wilderness, also following the specific guidelines issued by The International Union for Conservation of Nature (IUCN) “Policy Statement on Research Involving Species at Risk of Extinction”.

Conflict of interests The authors declare no competing interests.

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