UNIVERSITÀ DEGLI STUDI DI TORINO

Dipartimento di Scienze della Vita e Biologia dei Sistemi

Corso di Laurea in Biologia dell'Ambiente (LM-06)

Five years monitoring project of Eurpean Golden Jackal (*Canis aureus moreoticus*) in the Piedmontese Park of Po river

Matteo Angeli - 846994

Corso di Metodi di Campionamento Zoologico

A.A. 2022/2023

Contents

1 Introduction

The European Golden Jackal, *Canis aureus moreoticus* (Geoffroy, 1835), hereafter named as *C. aureus* or just jackal, is the largest subspecies of *C. aureus* (Linnaeus, 1758) species (Lapini, Conte, Zupan, Kozlan, et al., 2011). Its distribution in Europe its in continuous growth in the last 70 years. Starting from populations increase in Eastern Europe (Croatia and Bulgaria), three different range expansion events occurred: i. 20th century, toward North-Adriatic mainland; ii. around the 80s, the species appeared in Italy (1984, Udine), Slovenia, Austria, Hungary and Slovakia (Arnold et al., 2012); iii. a new expansion start in the first years of 21th century (Lapini et al., 2011). The causes of these great spatial expansions are all human-related, primarily the wolf extermination in Balkan peninsula (Spassov & Acosta-Pankov, 2019). In Italy, the actual monitoring data and direct evidences show a great expansion toward North West of the country (Lapini et al., 2011).

Probably arrived from North Istria, the Italian population is considered recent, since the first sight dates back to 1984, and the first reproduction was confirmed in 1985, near Udine. From the first appear, different studies follow the Italian distribution of the jackal (Lapini & Perco, 1988; Lapini, Perco, & Benussi, 1989; Boitani, Lovari, Vigna Taglianti, et al., 2003). Even if the first individuals were considered as vagrants male in juvenile dispersion, nowadays the *C. aureus* population is actually spread along the Pianura Padana, but with high variability in density.

1.1 Species description: Taxonomy, Biology, Ecology

The Golden Jackal is a medium-size Canidae, and different subspecies are spread from Europe to South-East Asia. The European subspecies is considered the largest one, taking into account the last consideration on the Egyptian subspecies *Canis aureus lupaster*, which is cryptic lineage of *Canis lupaster* (Rueness et al., 2011; Lapini et al., 2011).

Kingdom	*Animalia*
Phylum	*Chordata*
Class	*Mammalia*
Order	*Carnivora*
Family	*Canidae*
Genus	*Canis*
Species	*C. aureus*
Subspecies	*C. a. moreoticus*

Table 1: Taxonomy of the European Golden Jackal

With a body weight around 11-12 kg (max. 15 kg measured (Boitani et al., 2003)) (Lapini, Pecorella, Ferri, & Villa, 2021), and a total length of both sexes around 120-125 cm (Giannatos, 2004). The coat is usually reddish, golden-brown and silver-grey, but a variability is observable in the head and throat area of many individuals (Giannatos, 2004). Sexual dimorphism in fur color is absent, while in size and body mass, studies did not find great difference (e.g. male body mass 12% greater than female), in particular comparing the data to other canids (i.e. wolf and red fox) (Raichev et al., 2017).

Figure 1: *C. a. moreoticus*, Greece. Photo by Arendt and Schweiger, from Giannatos, 2004

The jackal is classified as mesocarnivore (i.e. carnivorous with a 50-70% meat-based diet; Lange, Lelieveld, & De Knegt, 2021), but is considered a generalist forager, since his diet is mainly based on small mammals (less than 50g, no evidence of prey selection), ungulates carcasses, small domestic animals and plants (Lange et al., 2021). The interaction with human settlements is not rare, in this case a large part of the diet is provided by garbage (Pecorella, 2021). This behaviour mad the jackal an example species of cleaner in anthropic sites, which is an important ecological service in peri-urban areas.

The jackal habitat is very variable and depend a lot on interactions with other species. Usually, the species is linked to wet areas, next to rivers of different sizes, and often next to anthropic sites (that furnish a great income of resources through foraging in peri-urban areas). During the reproductive period, the couple move to dense shrub or forest areas, where a lair is prepared in badgers' (*Meles meles*) burrows or other cavities (Lapini, Dreon, Caldana, Luca, & Villa, 2018). If the wolf is present in the area, forest and more covered areas became unavailable for the jackal. In these cases, besides river floodplains, non-intensive agricultural fields of any kind can be chosen (Lapini et al., 2018). In terms of vertical distribution, the species could spread at different altitude, with the highest observation in Alto Adige (North-East Italy) around 1700-1900 m a.m.s.l. (Pecorella & Lapini, 2015; Lapini, Caldana, & Amori, 2016). However, the majority of sightings in Italy show that a lower altitude is preferred (Lapini et al., 2011; Lapini & Rondinini, 2013).

The home range is very variable, and it is not equally controlled. Some of the areas, which are more covered in shrubs and used as diurnal resting spots and to find liars, are well protected. The foraging area instead, are less controlled, and next to urban areas are often shared by different groups of jackals. In fact, the home range of packs can vary in size

and overlap dependently to trophic resources (Fenton et al., 2021). It can vary from 20 to 1 km^2, and became smaller in presence of high density of resources (Macdonald, 1979).

The previous description is valid for the basic social unit. It is formed by the reproductive pair and the current-year litter, but usually one or few helper can follow the parents. These are 1-2 years old individuals, more often females (Demeter & Spassov, 1993), who delay their wandering behaviour, and so their possibilities reproduction (Pecorella, 2021). The males, around the age of 1 year, tend to leave the parental couple toward new areas. This wandering behaviour is considered the base that bring the actual expansion of the species in Europe (Pecorella, 2021).

1.2 Interactions with other Carnivore Species

Wolf

The jackal interaction with wolf (*Canis lupus* Linnaeus, 1758) is complicated, and mainly studied in its Balkan territory. At low level of population density, and so with low level of interaction, the coexistence seems to be possible (Lapini et al., 2021). If the population density raise, the jackal can suffer of competitive exclusion by the wolf. Past wolf extermination, had a strong positive effect on jackal populations (Fig. 2). Thanks to the application of conservation plans and the constant reduction of persecution of *C. lupus*, top-down suppression by the greater predator to the jackal, could led to a disappearance or a displacement of the smaller mesocarnivore (Krofel, Giannatos, Ćirovič, Stoyanov, & Newsome, 2017),. In Italy, competitive exclusion between wolf and jackal it is already known in North-East Italy (Magredi, Pordenone; Lapini et al., 2018).

Red Fox

In Hungary, the difference in diet between the jackal and the red fox (*Vulpes vulpes* Linnaeus, 1758), which is considered its primary competitor. Thanks to camera-trapping, different times meetings between fox and jackal were recorded and studied (L., 2014). Light interference between the species were proven when foraging areas of both coincide, but the mainly this led to an avoidant behaviour of the fox during the summer time (L., 2014; Shamoon, Saltz, & Dayan, 2017). In general, where jackal population density increase, the fox tend to decrease (Giannatos, Marinos, Maragou, & Catsadorakis, 2005).

Moreover, it is important to highlight that the morphological similarity between the golden jackal and the red fox, could led to a negative selection by human. In fact, in the first years of this century, two main threats for Italian jackal population were identifies: road-kill, and illegal shots, caused by mistakes in identification during culling operation (Lapini et al., 2011).

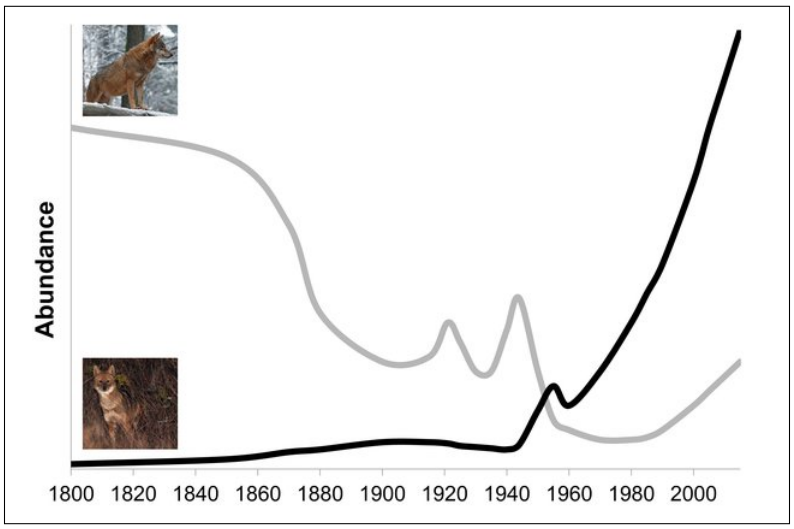

Figure 2: Schematic representation of relative abundance of *C. lupus* (grey line) and *C. a. moreoticus* (black line) in Balkans region, since 1800 (Krofel et al., 2017). For details on data source and interpretation see the source.

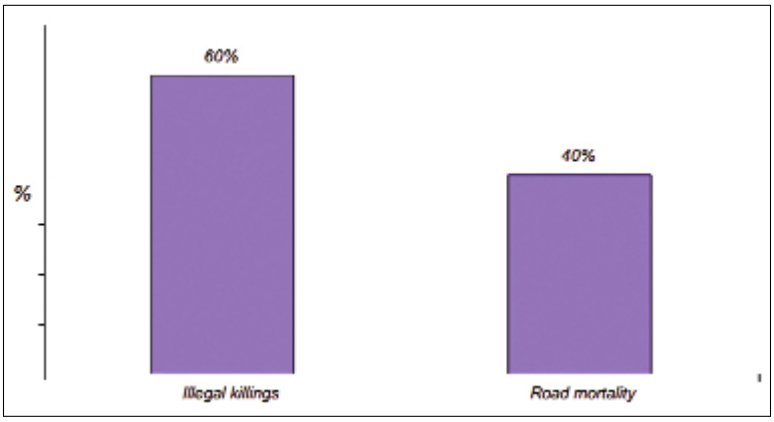

Figure 3: Mortality of the golden jackal in Italy from 1984 to February 10th, 2011. From Lapini et al., 2011; see the source for further information on data and analysis.

European Badger

Little is known about the interaction of *Meles meles*, the European Badger, and the Golden Jackal. Even if evidence of direct relation between the two species are poor, it is known that the jackal use often the burrow left by the mustelidae (Pecorella, 2021). Further studies, probably using camera traps, will probably explain more about this.

1.3 Legal Status

Internationally, the species is listed in the Annex V of Habitat Directive (92/43/EEC), and in the Appendix III of CITES. Although, in Croatia, Serbia, Hungary, Bulgaria and other Balkan peninsula's countries is considered hurtful, and so the jackal populations are highly controlled and limited in size and dispersion. At national level, the golden jackal is included in the Italian faunal list, and protected by the national Law n. 157/1992.

1.4 Project aims

Starting from the data of the Italian population, and from the most recent of *C. a. moreoticus* in Piemonte region, this document will provide a schematic plan for the monitoring of the species. The project is planned to start in November of 2023, and last for five year, continuously. The main aims, which will be divided in two independent phases, are here summarized in:

i. Quantity evaluation of the park's jackal population and estimation of jackal packs' home range

ii. Assessment of possible interaction with pastures

In order to complete these tasks, different methods are proposed in this document. Each technique will be briefly explained in terms of methods, materials and time required. At the end of this report, a summary about total cost (see 4) and human resources is provided.

2 Geographical Characterization of the Study Area

The Piedmontese Natural Park of Po river extends over an area of 11,777.65 ha, along the Piedmont region, within the provinces of Alessandria, Cuneo, Turin and Vercelli (for a total of 36 municipalities). The park area, protected since 1990 thanks to Piedmont regional law n.28. At the time, it was formed by different sites, managed by three different bodies, was subsequently unified into the Po Natural Park in 2019. The law of the Piedmont region n.11 of 2019 entrusted to the Entity of Management of the Protected Areas of the Piedmontese Po the protection of 8 areas: i. the natural park of the Piedmontese Po; ii. the Bosco della Partecipanza and Grange Vercellesi natural park; iii. the Superga hill natural park; iv. the Castelnuovo Scrivia reserve; v. the Torrente Orba natural reserve; vi. the Bosco del Vaj natural reserve; vii. the Mulino Vecchio natural reserve; viii. the natural of the Islet of Ritano.

2.1 Overview on Plant Community

The Park is characterized by its riparian vegetation, thanks to its proximity to the Po river which continues throughout the entire extension of the park.
There are numerous ecological entities that can be found linked to the river, speaking of environments in which water is always or almost always present, we have:

- **Sandbanks**, emerged portions of sand that appear when the river level is low, which can be colonized by annual plants such as *Vulpia myuros*, *Polygonum lapathifolium*, *Polygonum hydropiper* and by perennial stoloniferous plants.
- **Oxbows**, deposits of debris brought by the river, are always present and allow the growth of plants such as the *Nuphar* spp., *Nymphaea* sp., *Polygonum amphibium*, *Hydrocharis morsus-ranae* and *Salvinia natans*, which can grow undisturbed thanks to the low/absent water flow area.
- **Reedbeds**, made up of herbaceous plants, where the broadleaf cattail (Thypha latifolia) is mainly present, near which there are shrubby willows such as the cinereous willow (salix cinerea) and recently by an American weed shrub Amorpha fruticosa.
- **Irrigation canals**, which host plants suitable for the accentuated current of the canal flows such as *Potamogeton* spp., *Ranunculus fluitans* and *Ranunculus trichophyllus*.

Along and away from river's banks, in the plant community became more common:

- **Along banks of the Po**, characterized by tree species such as white willow (*Salix alba*) and silver poplar (*Populus alba*) which allow the stability of the banks during floods and allow the development of a thriving population of native herbaceous plants such as *Lythrum salicaria*, *Typhoides arundinacea*, *Carex pendula* and exotic species such as buddleia (*Buddleja davidii)* native to China, Jerusalem artichoke (*Helianthus tuberosus*), an exotic species from America and the South African senecio (*Senecio inaequidens*).
- **Hygrophilous woods of black alder** (*Alnus glutinosa*) which host an undergrowth mainly composed of black elderberry (*Sambucus nigra*), bluish bramble (*Rubus caesius*), ivy (*Hedera helix*), *Aegopodium podagraria*, *Solanum dulcamara*, *Athyrium filix-foemina* and *Helleborus viridis*.
- **Mixed forest of the plain** composed mainly of the elm (*Ulmus minor*) and, a little further from the water, the English oak (*Quercus robur*). In the tree layer of this area there are also black poplar (*Populus nigra*) and black locust (*Robinia pseudoacacia*) and in the shrubby layer dogwood (*Cornus sanguinea*) and hawthorn (*Crataegus monogyna*).
- **Toward the hill-side**, the oak-hornbeam forest (*Quercus robur, Q. petraea, Q. pubescens, Carpinus betulus*), beech forest (*Fagus spp.*) with *Acer pseudoplatanus*, *Fraxinus excelsior* and the massively introduced *Castanea sativa*.
- **The lean hay meadows** in the plains and hills, which are increasingly rare and semi-natural. They include, for example, tall oats (*Arrhenatherum elatius*) and *Crepis biennis*, *Knautia arvensis* . Towards the plain, the presence of annual caespica (*Erigeron annuus*), native to North America, is often noted.

2.2 Overview on Faunal Community

Fishes

It is worth underlining the presence of a proliferating population of grayling (*Thymallus thymallus*) and marble trout (*Salmo trutta marmoratus*), although it is in decline due to significant introductions of brown trout (*Salmo trutta*) for fishing purposes. In the city area there are numerous limnophilous cyprinids such as carp (*Cyprinus carpio*), *Leuciscus cephalus*, rudd (*Scardinus erythrophthalmus*) and bleak (Alburnus a. alborella). The presence of non-native species in the Po River should be noted, especially the *Silurus glanis* and *Aspius aspius*, which threaten the native species.

Invertebrates

In the park there is a great diversity of invertebrates, particularly aquatic, but even the presence of invasive alien species is highlighted: *Procrambus clarkii* and *Orconectes limosus* (more recently appeared), which threaten the native populations of *Austropotamobius pallipes*. As for pollinators, 350 spp have been identified in the park. of moths thanks to the monitoring started in 2019 by P. G. Varalda (further information on the park website). Furthermore, in the park there are spots of presence of *Lycaena dispar*, a species protected by the Habitat Directive (92/43/EEC; Annex II and IV).

Mammals

There are many mammals species that inhabit the Park. Common to observe are individuals of roe deer (*Capreolus capreolus*), badgers (*Meles meles*), foxes (*Vulpes vulpes*), red and gray squirrels (*Sciurus vulgaris and carolinensis*), hares (*Lepus europeus*), ground vole (*Arvicola terrestris*), stone marten (*Martes foina*) and marten, (*Martes martes*). Numerous bat species are also present in urban settlements (e.g. in Santa Maria Maddalena church, Casalborgone). Some specimens of wolves (*C. lupus*) have also been reported in hilly and plain environments (the park is a supporter of LIFE18 NAT/IT/000972 LIFE WOLFALSP EU).

Amphibians and Reptiles

In the protected areas of the Piedmont Po, due to the very low level of conservation of reptiles and amphibians, there are few species of high interest. Among these we can mention amphibians such as the great crested newt (*Triturus carnifex*), common newt (*Triturus vulgaris meridionalis*), tree frog (*Hyla arborea*), Lataste's frog (*Rana latastei*), and the pelobate toad (*Pelobates fuscus*).

Among the reptiles, however, there is the pond turtle (*Emys orbicularis*), once much more present and currently disappeared in some sites of the park. *Trachemys scripta*, of North American origin, is increasingly frequent.

Birds

The park has a very rich avifauna, as the park area is a preferential nesting and wintering point for birds. Among the species present, divided by type of habitat we find:

- Oxbows - *Podiceps nigricollis*, the bittern (*Botarus stellaris*), the red heron (*Ardea purpurea*)
- Poplar woods - *Falco subbuteo* and the common owl (*Asio otus*)
- Hilly woods - the sparrowhawk (*Accipiter nisus*) and goshawk (*Accipiter genitilis*), and various species of woodpecker, including (*Sitta europea*).

2.3 Description of the Park through Geographic Informative Systems

Thanks to the Geographic Informative Systems, different aspects of the area could be examined. The subsequent maps describe the park area under different point of view:

i. Fig.4 - Map of the Park, divided by single area's name, and position relatively to North-West Italy map

ii. Fig.5 - Map of the Park, colorized under Corine Land Cover (Copernicus, 2018) code (three level of precision, 2018 data)

iii. Fig.6 - Altimetry of the Park area and nearby territory

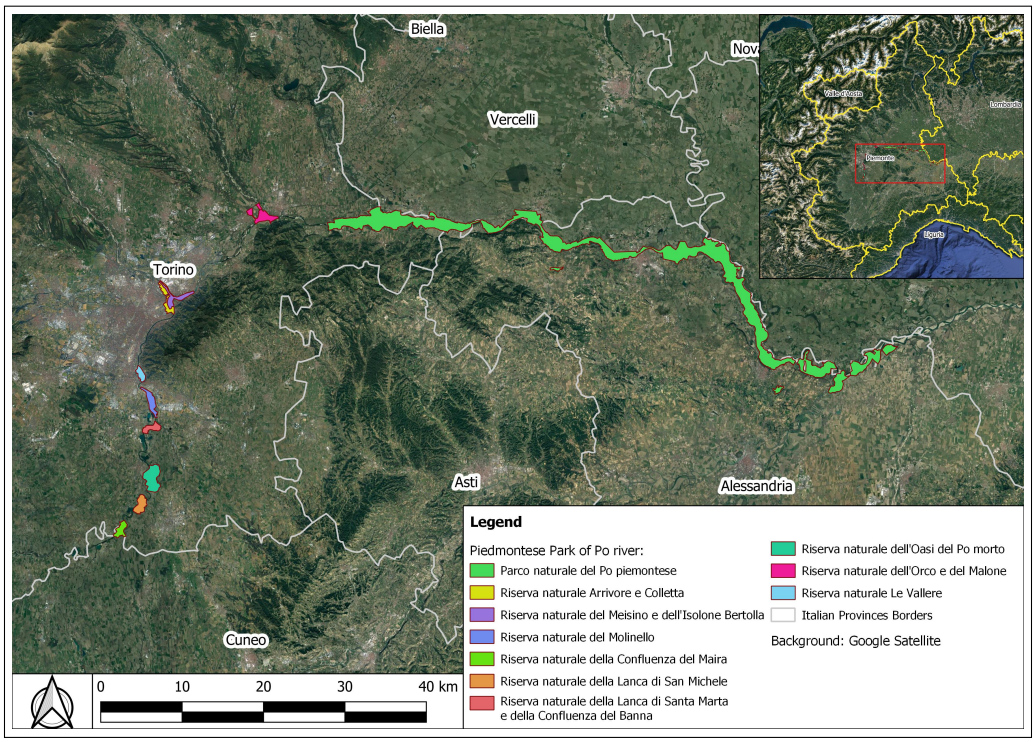

Figure 4: Map of Piedmontese Park of Po river. Different area were colored under the single name of the sites. In the top-right corner, the red square show the general position of the park, relatively to North-West Italy.

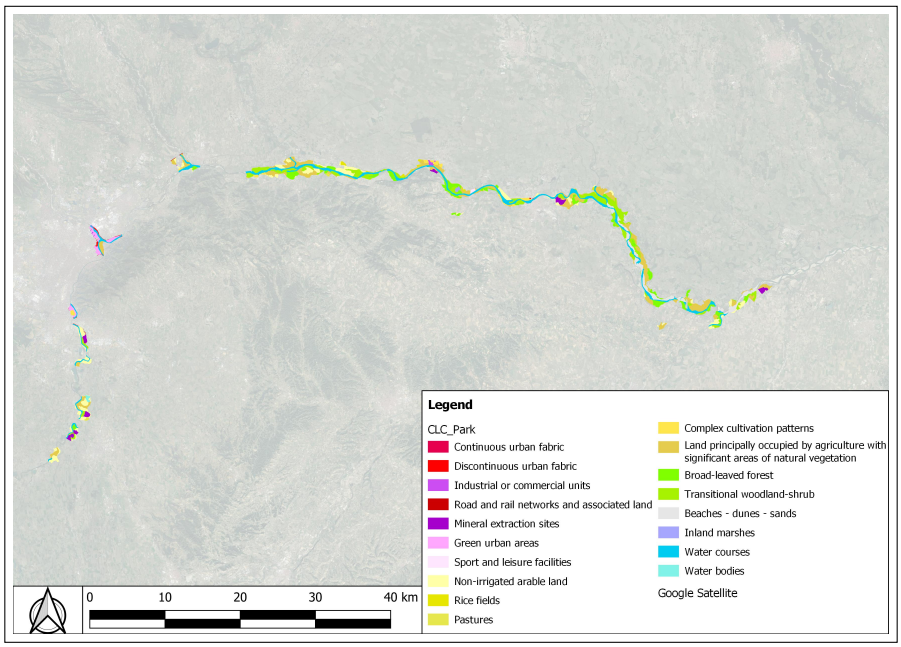

Figure 5: Map of the park, colored by soil use. Data from Corine Land Cover 2018. More information below (Tab. 2).

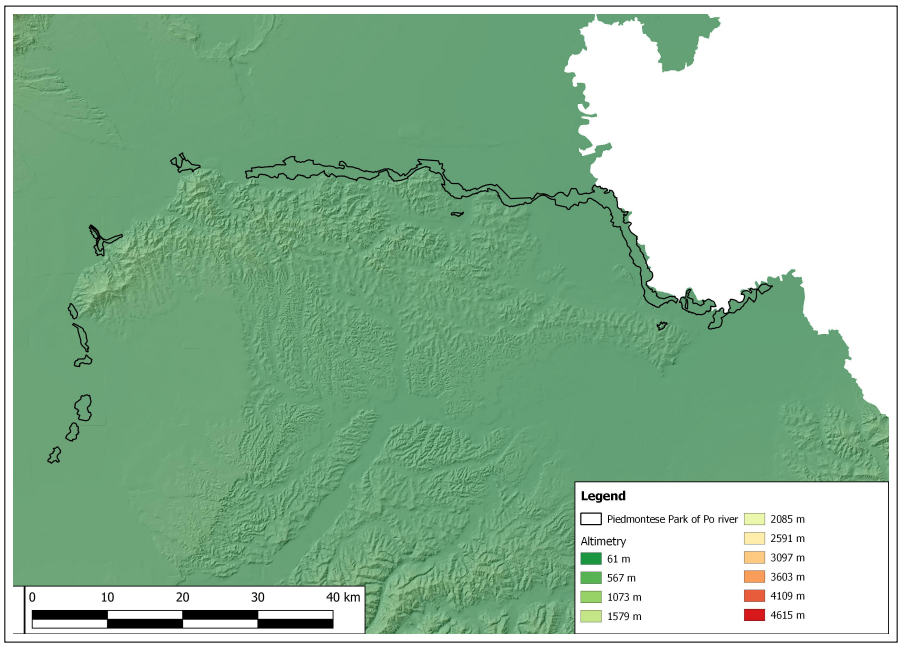

Figure 6: Altimetry map of the Park and the territory of Piemonte region. Data of altimetry (classified by colour as legend shows) from GeoPortale Piemonte `http://geoportale.piemonte.it`

CLC code	Area (ha)	Area (%)	Label
111	0.000 *	0.000 *	Continuous urban fabric
112	59.568	0.505	Discontinuous urban fabric
121	53.108	0.451	Industrial or commercial units
122	12.477	0.106	Road and rail networks and associated land
131	352.127	2.988	Mineral extraction sites
141	245.651	2.084	Green urban areas
142	27.523	0.234	Sport and leisure facilities
211	1607.676	13.641	Non-irrigated arable land
213	135.433	1.149	Rice fields
231	38.271	0.325	Pastures
242	263.890	2.239	Complex cultivation patterns
243	2722.924	23.103	Land principally occupied by agriculture with significant areas of natural vegetation
311	1316.246	11.168	Broad-leaved forest
324	1849.421	15.692	Transitional woodland-shrub
331	695.481	5.901	Beaches - dunes - sands
411	32.452	0.275	Inland marshes
511	2337.067	19.829	Water courses
512	36.615	0.311	Water bodies

Table 2: Corine Land Cover classification (2018, three level) of the Park area. Area in hectare and percentage on the total, were calculated by type.
(*) This type of area was present, rounding operation made it zero (5.7e-06 ha)

These maps were the first geographical analysis which provide information on the Park area and led to the design of transects and the first camera-traps placing sites.

3 Monitoring: Material and Methods

In this section, every monitoring and sampling method will be explained in terms of material, human resources and timing. It is important to notice that, unless strictly indicated, every method is independent each other. The only premise common to every technique hereafter listed, is the training of operative staff. This report intend to propose the start of the monitoring period in November 2023, and so the training time in October (2 weeks, adaptable). During this weeks, the website related to the second phase (Sec. 3.2) will be planned and public events in the area will be evaluated.

To resume, the aim of this project are: i. Quantitative estimation of the jackal population; ii. Pack's home range; iii. Interaction with pastures. The methods available today to answer to these questions are different. Moreover, since quantitative data in this area are missing, it is necessary to enhance the sampling effort as much as possible, using all the available time. For this reasons, the two main goals (and so the techniques) will be not grouped or ordered. Instead, it is suggested to perform the subsequent investigation independently each other.

In Europe, the standards to monitor and to obtain samples for molecular studies on *C. aureus*, were described by Hatlauf, Banea, & Lapini, 2016. This protocol is followed by every country in the EU community recently colonized by the jackal (Lapini et al., 2021), in particular by the *GOlden JAckal informal study Group in Europe* (GOJAGE). The 2016 document was taken into account for draft of this project in the Po River Park. Every data, even the one obtained through the citizen-science part of the project (Sec. 3.2), will be categorized under the categories (Fig. 7) from (Hatlauf et al., 2016). For the first phase, only the data evaluated as C1 (Strong Evidences) will be used, while for the second phase even the C2 (Verified Evidence) and C3 (Weak Evidence) categories will be accepted at first.

Resume of Monitoring Methods

- First Phase: Abundance and Home Range
  - Snow-tracking, Linear Transects and Genetic Analysis
  - Jackal-howling
  - Camera-trapping
- Second Phase: Pastures Interaction Assessment
  - Data sampling through Citizen Science
  - Public Events and Communication
  - Data Selection and Analysis

Category Nr & Name	**GOJAGE Expert / Non-Expert Criteria** *modified from SCALP*	**GOJAGE Expert Criteria** *number of methods with positive results assessed always by experts*
C1 **Strong Evidence**	Unchallenged observations from experts "hard facts" e.g. all reports of golden jackals killed or found dead and photographs taken by **experts**	- three indirect methods OR - one direct method
C2 **Verified Evidence**	Sightings, records of tracks and droppings → if reported or verified by **experts**	- three indirect methods
C3 **Weak Evidence**	Sightings, records of tracks and droppings → reported by **non-experts** as well as all sightings and spontaneous howls that cannot be verified	- two indirect methods
C4 **No Evidence**	Sightings, records of tracks and droppings → reported by **non-experts** as well as all sightings and spontaneous howls that cannot be verified	- no method

Figure 7: GOJAGE categories, modified from SCALP (Status and Conservation of the Alpine Lynx Population; Molinari-Jobin et al., 2003). Table from Hatlauf et al., 2016.

3.1 First Phase: Abundance and Home Range

3.1.1 Snow-Tracking

The snow tracking will be the first monitoring operation that will start, after the training course. Since it is strictly depend to the weather condition, it is not possible to foresee the number of times will be repeated. In the best conditions, the operation of monitoring through jackal's tracks on the snow (such as paw-print, faeces and hairs), will be executed along the linear transect, between the 15th of November to the 15th of March. The pathways that need to be followed are the same used for the Linear Transect Methods (Sec. 3.1.2). The map below (Fig. 8) show exactly the location of the paths. More information of the transects in the next sub-section. For each transect, one operator will follow the path once per day. The operator will wait 24 hours from the last snow in the area.

Once a track will be identified, the operator will take a picture of the paw print. Some measurement need to be made, in order to classify the species: paw print shape and size, the stride and the positioning of the prints (Torretta et al., 2020). In the case where, size and the other measures seems to be strictly linked to a jackal specimen, they will be discarded on site. After recorded the GPS position, the operator need to follow forwards and backwards the tracks, and record the position every second (automatically made with a function included in the Garmin eTrex 20x, the tool chosen).

If scats, hairs or some organic rest will be find, it is mandatory to take a sample. About the jackal scats, the average length observed is 5–38 cm (mean ± SE = 21.8 ± 1.5 cm, Torretta et al., 2020). For the species-assignment, if the length is less then 13-14 cm, will be rejected, since it could be fox-faeces. Circa 3-4 cm of scat will be taken after positive identification. Every organic sample attributable to the jackal will be collected in plastic container, filled in part with silica-gel (in order to preserve the sample). These sample will be used for genetic analysis (Sec. 3.1.3). Thanks to this method, information on number of individuals and reproductive couple (and social groups in general) will be obtained.

3.1.2 Linear Transect Methods

In order to confirm the presence and to obtain quantitative data on the jackal in the park area, the Linear Transect Method is the most solid one. The method will be applied similarly to the snow-tracking, described previously. One operator each transect, will follow the pathways (Fig. 8). All the path will be surveyed at the same time, by six independent operator. The method will be performed once every two weeks, every month between April and October. In case of hot autumn and winter, with zero or almost of snowing events, the method will be performed even during the rest of the year

The operator will provide GPS position, picture and notes on every organic sample will found. Scats and hairs will be taken in the same way previously described. Moreover, in case of carcasses suspected to be scavenged or killed by a jackal, a section nearby teeth-print will be removed and preserved in a plastic tube, with silica gel. Picture and GPS location of the entire prey, measures of bites and identification of the dead animal will be also note down.

Every organic material need to be delivered by hand as soon as possible, in order to preserve at best the sampling, and to be catalogued. After reaching a certain amount of sampling, they will be prepared for genetic analysis.

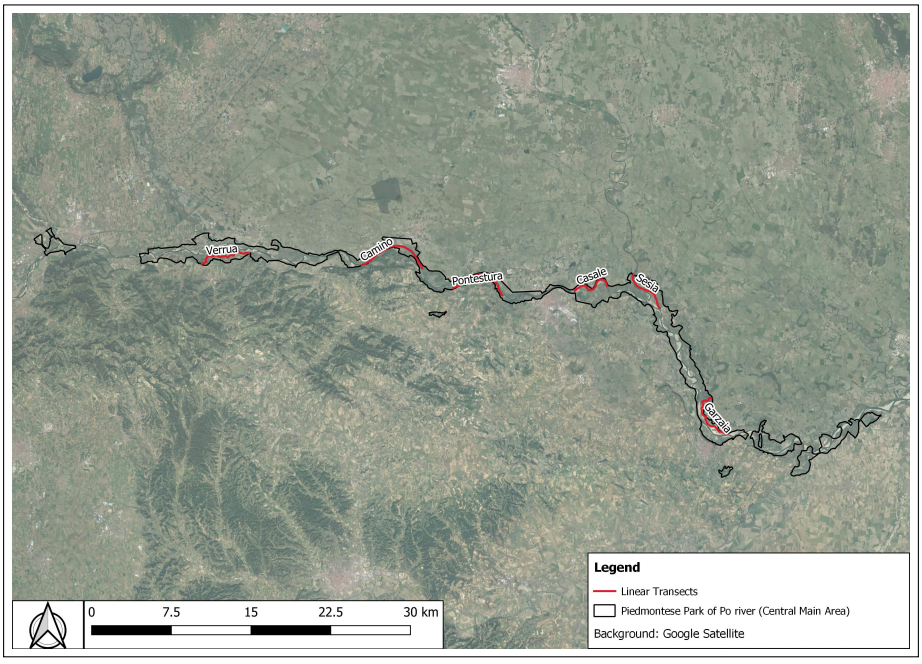

Figure 8: Map that shows Linear Transects that operator will follow during Snow-tracking and Linear Transects Methods.

Name	Length	Location
Verrua	5832 m	Verrua
Camino	7206 m	Frazione Rocca delle Donne (Camino Monferrato)
Pontestura	6076 m	Pontestura
Casale	4305 m	Casale Monferrato
Sesia	4323 m	Confluence of Sesia and Po rivers
Garzaia	6112 m	Integrated Natural Reserve of Garzaia di Valenza
Average	5647 m	- - -

Table 3: Resume of length and location of the linear transects (Fig. 8)

3.1.3 Genetic Analysis

During the linear transect and the snow-tracking method, it is extremely important to remember to observe some rules, in order to avoid failures during genetic analysis:

- The operator need to use plastic gloves, one pair every sample
- Natural object (e.g. wood sticks or rocks) can be used to help the extraction of the sample
- The operator need to avoid any indirect contact or any way it can compromise the sample (e.g. heavy breath)

Once collected, organized, associated with on-field data and stored in a freezer, organic samples will be ready to perform genetic analysis. These analysis will be performed by University of Turin (Department of Life Science and System Biology), once every two month. In the remote case that an operator will found a carcass of a golden jackal, the body will be reported by the operator, and later moved to the Department of Veterinary Science (University of Turin), in order to confirm the death cause and to obtain sample for genetic analysis.

Thanks to the second phase of the project (Sec. 3.2), sample of DNA could be also obtained under citizens reports. In case of suspect domestic animals killed by jackal, one operator could reach the location an extract samples. This would be possible only if the owner of the livestock will preserve the corpse, without touching it directly and trying to limit the external factors that could led to a loss in sample quality.

3.1.4 Jackal-howling

The Jackal-howling is considered one of the best tool to identify and monitor the social groups of *Canis aureus* (Lapini et al., 2018; Giannatos et al., 2005). Unfortunately, since in the Park were observed different individual of wolves. Since it is the greater predator of the jackal, the presence of *C. lupus* could affect negatively the results of the jackal-howling method.

Under suggestion of the GOJAGE, this method could be used but it tends to fail in condition of elevated stress of the golden jackal. In this case, the wolf population in and around the Park area, could inhibit the jackals response to the call-backs. Since they will try to not answer often, the GOJAGE group suggest to not stimulate the same group more than once every 2-3 months. Under these observation, this method will be performed according to this rule: every group will be acoustically stimulated every 2 months (6 repetition/month). At the end of the project, if no group will be lost and most of the stable one will be found, for each group there will be enough data.

The BioAcoustic Monitor (BAM), or jackal-howling, will be performed by reproducing a species-specific sound, from one or more animal. The method needs to be performed from different selected points, were the presence of social groups is assessed. The suggestion is to start with one call session in every point, following the map were camera traps will be placed (Fig. 10). After obtaining a good answer from a group of individuals, records of the call-back could be used for calculation and modelling the individuals numbers (Hatlauf & Böcker, 2022). In order to obtain quantitative information of the jackal's groups, an operator with greater experience need to be present, or it is necessary for a later analysis of the acoustic records.

3.1.5 Camera-trapping

The camera (model Cuddeback C2 IR) will be placed in the sites showed in the map below (Fig. 10. After the first placement of the camera, the maintenance will be every 3 months, were batteries and memory will be replaced. In order to reduce motion blur and to best perform its job, camera need to be placed at 40 cm from ground level, and at acute angle from the road (Hatlauf & Böcker, 2022).

Since they will be placed in public and hided place, the camera need mechanical protection. They need be anchored to a trees with chain and locked within a metal container. During every three-monthly check, the operator must be ensure the good condition of the protective box.

The location of the first camera placement needs to be considered as a first try, from ecology studies on the species, and territory observation through GIS tools. Further information, collected within the first semester of the first year, could modify the position of the camera.

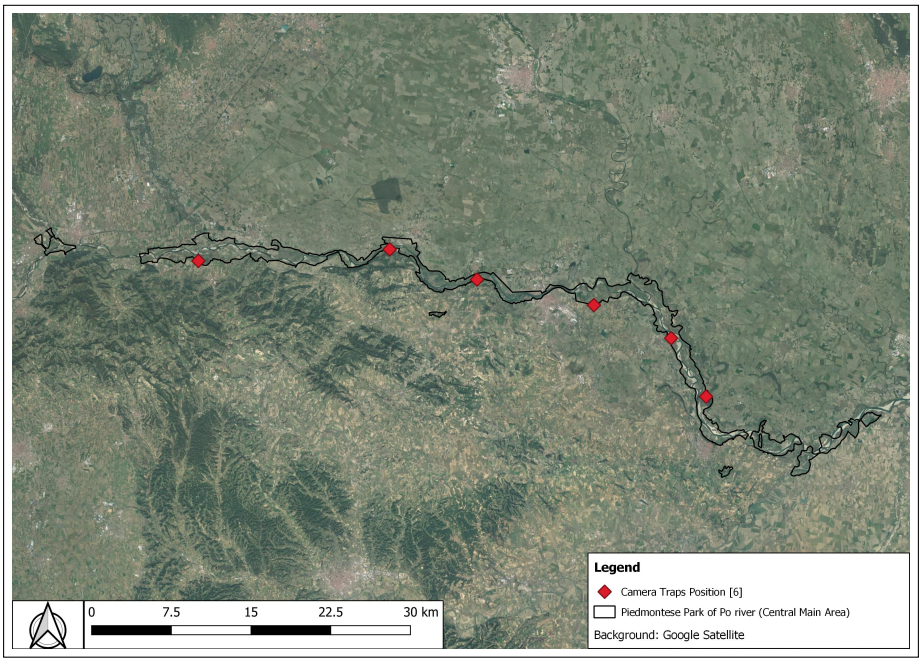

Figure 10: Map that show the location of camera traps. As explained above, these are just the first location, further data will provide more information and camera will moved.

3.1.6 Final Results

At the end of every year, a summary of the data will be performed. Every collected information on presence, number of individuals and reproductive groups, will be analyzed. Thanks to the different monitoring methods, quantitative analysis will be performed in order to estimate the population size. Thanks to camera-trapping and the different data they will provide whenever they will be moved, the home-range will be estimated through Kernel Density Estimation and Minimum Convex Polygon. Thanks to the genetic data, information about immigration of new individuals will be collected too.

Figure 9: The camera: Cuddeback C2 IR

3.2 Second phase: Interaction with pastures

The events of direct predation on ovine pastures are rare, and on domestic is often just theorized (Lapini et al., 2018). Other studies on jackal diet, e.g. in Hungary (Lanszki et al., 2016), observe that no calves were ever eaten, but domestic dogs and cats.

In order to collect data on predation events in the Park area, a citizen-science-like side project could be used. Since nowadays the availability of smartphones and security camera is at the maximum levels, citizens participation could bring safer and solid data on species presence and behaviour.

For these reasons, an official website of the monitoring project will be created, with two main functions: i. Informative; ii. Data Sampling. The website will provide two main pages, in order to achieve the main goal. A first, brief description of the species (morphological and behavioural), its ecological value and updates on the project itself. Secondly,an user-friendly web form, where every user could upload observation (pictures and videos) of the jackal, providing location and information about the sighting. The objective would be to collect data on predation events on livestock, and with positive results, to build a communication web between the breeders. After the collection, data will be classified under GOJAGE protocol (Hatlauf et al., 2016), and the one evaluated under the C1 and C2 categories will be automatically considered. The C3 quality data will need to be analysed carefully by experts and excluded if any doubt occur. Once per week, every week, an operator will categorize every information obtained.

In order to work, this project need to be known and spread as much as possible through the Park area and the nearby territory. The best options can be categorized as: i. Digital Communication; ii. On-site Communication.

The Park itself need to share on its website all the information related to the monitoring project. Moreover, the official website of the Park could be used to publicize the website of the project and the events where it will be present and the news about it. During the year, different events occur in the Park area: in order to enhance the knowledge about the monitoring of *C. aureus*, a sub-group of the staff could join these events. A stand with flyers, posters and information, will be placed during this community-event. This will provide more information directly to the people who live in the Park area and in the nearby territories. In addition to an increase of knowledge and sensibility on jackal conservation, these events will help to spread the website and its role in data-collection.

In future, if the possibility of interaction with livestock will be confirmed and quantitatively estimated, this website could help to create a healthy cohabitation in human settlements. The strong linkage that this tool could provide between researchers and the local population. Further project with the aim of conservation of the jackal with a focus on livestock, could use the information gathered from the locals to prevent the interaction and/or provide some useful tips to reduce the damages.

4 Economic prospectus

Hereafter, two table present a first economical prospectus. Costs were divided between materials/tools and human resources. Cost per quantity and salary per job are also displayed. Some of the arguments were dependent on field work first data or are unpredictable (e.g. weather dependent snow-tracking), but the salary and cost of material it is partially present too. Under this first analysis, the cost of

4.1 Cost of materials and tools: resume table

	Materials	**Quantity**	**Cost (per unit)**
I	Garmin eTrex 20x	6	1020 (170) €
	AA Rechargeable GPS Batteries (2 ea.) AA Rechargeable Camera Batteries (16 ea.)	5 pack (24 unit/pack)	160 (32) €
	Camera Cuddeback C2 IR	6	1500 (250) €
	Metal Container (1 ea. camera)	6	240 (40) €
	SD Memory (32GB - 2 ea. camera)	12	60 (5) €
	Chains & Locks (1 ea. camera)	6	120 (20) €
	Organic Samples Container	150	750 (5) €
	Silica Gel	2 kg	60 (30/kg) €
II	Project Website	1	200 €
	Website Maintenance	1	200 €
	Public Events	15 (3/year)	1500 (100) €
	Public Events' material (e.g. flyers)	-	500 €
	Total	**-**	**6310 €**

Table 4: Table of material/tool costs for the monitoring project, divided into phases.

4.2 Cost of human resources: resume table

	Job	Operator x Times	Salary (single time)	Total	Notes
	Training	6 x 10	100 €	6000	10 days
I	Linear Transects	6 x 120	150 €	108,000 €	
	Snow-Tracking	NA	150 €	NA	Weather Dependent
	Genetic Analysis	NA	75 €	NA	Sample Dependent
	Jackal Howling (1)	6 x 1	150 €	900 €	First Time
	Jackal Howling	NA	150 €	NA	Groups Dependent
	Camera-trapping (1)	2 x 3	150 €	900 €	First Time
	Camera-trapping	3 x 120	150 €	54,000 €	Maneteinance
II	Public Events	3 x 15	100 €	6,750 €	15 supposed
	Data Evaluation	1 x 260	120 €	31,200 €	1 per week
	Total			**207,750 €**	

Table 5: Table of costs in terms of human resources, divided by monitoring operations and phases.

References

Arnold, J., Humer, A., Heltai, M., Murariu, D., Spassov, N., & Hacklaender, K. (2012). Current status and distribution of golden jackals canis aureus in europe. *Mammal Review*, *42*(1), 1–11.

Boitani, L., Lovari, S., Vigna Taglianti, A., et al. (2003). *Fauna d'italia. mammalia iii. carnivora-artiodactyla (wildlife of italy. carnivores and artiodactyles).* Edagricole.

Copernicus. (2018). *Corine land cover* (Tech. Rep.). https://land.copernicus.eu/pan-european/corine-land-cover: European Environment Agency - European Union.

Demeter, A., & Spassov, N. (1993). Canis aureus linnaeus, 1758-schakal, goldschakal. *Handbuch der Säugetiere Europas*, *5*, 107–138.

Fenton, S., Moorcroft, P. R., Ćirović, D., Lanszki, J., Heltai, M., Cagnacci, F., ... others (2021). Movement, space-use and resource preferences of european golden jackals in human-dominated landscapes: insights from a telemetry study. *Mammalian Biology*, *101*, 619–630.

Giannatos, G. (2004). *Conservation action plan for the golden jackal canis aureus l. in greece.* (Tech. Rep.). WWF Greece.

Giannatos, G., Marinos, Y., Maragou, P., & Catsadorakis, G. (2005). The status of the golden jackal (canis aureus l.) in greece. *Belgian journal of zoology*, *135*(2), 145.

Hatlauf, J., Banea, O. C., & Lapini, L. (2016). Assessment of golden jackal species (canis aureus, l. 1758) records in natural areas out of their known historic range. *OJAGE Golden Jackal Informal Study Group Europe. GOJAGE eBulletin*, *12*.

Hatlauf, J., & Böcker, F. (2022). *Recommendations for the documentation and assessment of golden jackal (canis aureus) records in europe*.

Krofel, M., Giannatos, G., Ćirovič, D., Stoyanov, S., & Newsome, T. M. (2017). Golden jackal expansion in europe: a case of mesopredator release triggered by continent-wide wolf persecution? *Hystrix, the Italian Journal of Mammalogy*, *28*(1), 9–15. Retrieved from `https://doi.org/10.4404/hystrix-28.1-11819` doi: 10.4404/hystrix-28.1-11819

L., P. S. . L. (2014). Camera-trapping of the golden jackal (canis aureus moreoticus): data from italian karst (north-eastern italy, gorizia province). *Bollettino del Museo Civico di Storia Naturale di Venezia*, *65*(2014), 215-227.

Lange, P. N., Lelieveld, G., & De Knegt, H. J. (2021). Diet composition of the golden jackal canis aureus in south-east europe–a review. *Mammal Review*, *51*(2), 207–213.

Lanszki, J., Kurys, A., Szabó, L., Nagyapáti, N., Porter, L. B., & Heltai, M. (2016). Diet composition of the golden jackal and the sympatric red fox in an agricultural area (hungary). *Folia Zoologica*, *65*(4), 310–322.

Lapini, L., Caldana, M., & Amori, G. (2016). Evolution and trends of the populations of canis aureus moreoticus in italy. *Hystrix*, *27*, 110.

Lapini, L., Conte, D., Zupan, M., Kozlan, L., et al. (2011). Italian jackals 1984-2011: an updated review (canis aureus: Carnivora, canidae). *Bollettino del Museo Civico di*

Storia Naturale di Venezia, *62*(2011), 219–232.

Lapini, L., Dreon, A., Caldana, M., Luca, M., & Villa, M. (2018). Distribuzione, espansione e problemi di conservazione di canis aureus in italia (carnivora: Canidae). *Quaderni del Museo Civico di Storia Naturale di Ferrara*, *6*(2018), 89–96.

Lapini, L., Pecorella, S., Ferri, M., & Villa, M. (2021). Panoramica aggiornata delle conoscenze su canis aureus in italia. *Quaderni del Museo Civico di Storia Naturale di Ferrara*, *9*, 123–132.

Lapini, L., & Perco, F. (1988). Primi dati sullo sciacallo dorato (canis aureus linnaeus, 1758) in italia (mammalia, carnivora, canidae). *Atti del I Conv. Naz. dei Biologi della Selvaggina, Suppl. Ric. di Biol. della Selvaggina*, *14*, 627–628.

Lapini, L., Perco, F., & Benussi, E. (1989). Lo sciacallo dorato (canis aureus l., 1758), specie nuova per la fauna italiana (mammalia, carnivora, canidae). *Gortania-Atti Museo Friul. Storia Nat*, *10*(88), 213–228.

Lapini, L., & Rondinini, C. (2013). Canis aureus. *Liste Rosse italiane IUCN Federparchi, Italy*. Retrieved from `Availableonline:http://www.iucn.it/scheda.php?id=128228144,accessedon26thMarch2014`

Macdonald, D. W. (1979). The flexible social system of the golden jackal, canis aureus. *Behavioral Ecology and Sociobiology*, *5*, 17–38.

Molinari-Jobin, A., Molinari, P., Breitenmoser, C., Wölfl, M., Stanisa, C., Fasel, M., ... Breitenmoser, U. (2003, 01). Pan-alpine conservation strategy for lynx. *Nat. Environ.*, *130*.

Pecorella, S. (2021). Lo sciacallo dorato europeo (canis aureus moreoticus) in friuli venezia giulia: osservazioni descrittive da camera trapping opportunistico nel periodo riproduttivo. *Atti del Museo Civico di Storia Naturale di Trieste*, *62*, 247–260.

Pecorella, S., & Lapini, L. (2015). Camera trapping of the golden jackal (canis aureus moreoticus): data from italian karst (north-eastern italy, gorizia province). *Boll Mus St Nat Venezia*, *65*, 215–227.

Raichev, E., Peeva, S., Masuda, R., Kaneko, Y., Tsunoda, H., Georgiev, D., & Georgiev, D. (2017). Sexual dimorphism in body parameters of the golden jackal canis aureus l., 1758 (carnivora, canidae) in the sarnena sredna gora mountain and thracian plain (bulgaria). *Trakia Journal of Sciences*, *15*(2), 135.

Rueness, E. K., Asmyhr, M. G., Sillero-Zubiri, C., Macdonald, D. W., Bekele, A., Atickem, A., & Stenseth, N. C. (2011). The cryptic african wolf: Canis aureus lupaster is not a golden jackal and is not endemic to egypt. *PLoS One*, *6*(1), e16385.

Shamoon, H., Saltz, D., & Dayan, T. (2017). Fine-scale temporal and spatial population fluctuations of medium sized carnivores in a mediterranean agricultural matrix. *Landscape Ecology*, *32*, 1243–1256.

Spassov, N., & Acosta-Pankov, I. (2019). Dispersal history of the golden jackal (canis aureus moreoticus geoffroy, 1835) in europe and possible causes of its recent population explosion. *Biodiversity data journal*, *7*.

Torretta, E., Dondina, O., Delfoco, C., Riboldi, L., Orioli, V., Lapini, L., & Meriggi, A. (2020). First assessment of habitat suitability and connectivity for the golden jackal in north-eastern italy. *Mammalian Biology*, *100*, 631–643.