Is the grey wolf a potential predator of Eurasian beavers in Central Italy?

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IS THE GREY WOLF A POTENTIAL PREDATOR OF EURASIAN BEAVERS IN CENTRAL ITALY?

IL LUPO È UN PREDATORE DEL CASTORO EUROPEO IN ITALIA CENTRALE?

Riassunto breve - Il castoro eurasiatico *Castor fiber* si è estinto in gran parte dell'Europa tra il Medioevo e il XIX secolo. A partire dagli inizi del 1900, leggi di protezione e reintroduzioni autorizzate/non autorizzate hanno avuto luogo in gran parte degli stati europei e la popolazione di questa specie è ora diffusa tra la Spagna settentrionale e la Mongolia occidentale. In Europa, il principale predatore del castoro eurasiatico è il lupo *Canis lupus*. In questo lavoro preliminare, abbiamo studiato la dieta del lupo in un'area fluviale dell'Italia centrale (provincia di Arezzo), dove un nucleo di castoro europeo è presente almeno dal 2019. Abbiamo raccolto 69 escrementi tra il 2021 e il 2022. Non abbiamo trovato alcuna prova di consumo di castoro da parte del lupo: le principali prede nell'area di studio sono risultate il cinghiale *Sus scrofa* e la nutria *Myocastor coypus*, seguiti da ovini domestici *Ovis aries* e cervidi.
Parole chiave: - *Canis lupus*; *Castor fiber*; alimentazione; frequenza relativa; volume relativo; ricolonizzazione dell'Italia.

Abstract - *The Eurasian beaver* Castor fiber *went extinct throughout most of Europe between Medieval times and the XIX century. Since early 1900, protection laws and authorised/unauthorised reintroductions have occurred in most countries and the population of this species is now widespread between Northern Spain and Western Mongolia. In Europe, the main predator of the Eurasian beaver is the grey wolf* Canis lupus. *In this preliminary work, we aimed to assess the wolf diet in an area of Central Italy where beavers occurred at least since 2019. We collected 69 scats in a riverine area in the province of Arezzo between 2021 and 2022. We did not find any evidence of beaver consumption: the main prey species in the study area were the wild boar* Sus scrofa *and the coypu* Myocastor coypus, *followed by domestic sheep* Ovis aries *and cervids.*
Key words - Canis lupus; Castor fiber; *diet; relative frequency; relative volume; Italian recolonization.*

Introduction

Both the grey wolf Canis lupus and the Eurasian beaver *Castor fiber* have been for long persecuted by humans throughout their European range since Medieval times, the former as a potential predator of livestock (Dufresnes et al. 2018), the latter for crop damage, fur and castoreum (Stringer & Gaywood 2016; Halley et al. 2021).

In the last 50 years, also thanks to specific protection laws, both the wolf and the beaver recovered their populations throughout Europe, the former also following forest re-expansion (Salvatori & Linnell 2005; Chapron et al. 2014) and the latter also helped by official and unofficial release programs (Halley et al. 2021). Currently, wolves and beavers coexist in most Central and Eastern Europe (Boitani et al. 2018; Halley et al. 2021).

In line with the rest of Europe, also in Italy, the wolf was confined south of the Alps since the turn of the last century, reduced to about 100 individuals in two fragmented subpopulations in the central-southern Apennines in the late 1970s (Fabbri et al.

2007; Loy et al. 2019). In 2020-2021, a nationwide wolf survey coordinated by the Italian National Institute for Environmental Protection and Research (ISPRA – Istituto Superiore per la Protezione e la Ricerca Ambientale) reported the presence of wolves in all peninsular Italian regions, counting about 3300 individuals (Aragno et al. 2022).

The recolonisation of Italy by the Eurasian beaver, instead, is still in the early stages (Loy et al. 2019). After reintroduction events in Switzerland and Austria (cf. Halley et al. 2021), one individual reached North-Eastern Italy in 2018 (Friuli Venezia Giulia: Pontarini et al. 2018) and one/two individuals currently occur also in Val Pusteria (Alto Adige). At least since 2019, more than two reproductive populations of Eurasian beaver also occur in Central Italy, in the Ombrone-Merse and the Tevere river basins (Mori et al. 2021; Pucci et al. 2021; Viviano et al. 2022). Thus, in both these areas, beavers coexist with wolves.

Grey wolves are opportunistic carnivores, feeding on a wide range of prey species, mostly wild ungulates and large-sized rodents (Newsome et al. 2016). In Central and Eastern Europe, beavers represent an

important prey for the wolf, particularly in warmer months when the water level is the lowest (e.g. Gable et al. 2017, Sidorovich et al. 2017).

In Italy, Mori et al. (2017) reviewed 16 papers on the wolf diet in Italy and reported that the wild boar *Sus scrofa* was the main prey of the wolf (49% occurrence, on average), followed by roe deer *Capreolus capreolus* (24%), and livestock. Afterward, it has been shown that wolves may locally adapt to different prey like large wild ungulates and large rodents (e.g. the coypu *Myocastor coypus* in Central Italy and the crested porcupine *Hystrix cristata* in Southern regions: Ferretti et al. 2019; Rizzardini & Quinto 2022). Therefore, in this work, we aimed at determining the wolf diet in coexistence with Eurasian beavers in Central Italy, to assess whether this large rodent is already included in the diet of the carnivore. Particularly, due to the severe drought which occurred in the winter of 2021-2022, we predicted that wolves may have increased their hunting behaviour near wetlands (cf. Sidorovich et al. 2017), thus potentially including also beavers in their diet.

Materials and methods

A total of 69 wolf scats was collected in 2021-2022 along a fixed itinerary (13 km long) in the Area Naturale Protette di Interesse Locale "Golena del Tevere" (Code: APAR06; 175000 ha, 43.57°N – 12.06°E), south to the Montedoglio Dam, in the municipalities of Sansepolcro and Anghiari (province of Arezzo, Central Italy; Figure 1).

This area is an important wetland along the Tevere river, composed of several ponds surrounded by woodlands, mostly composed by *Salix alba* L., *Salix purpurea* L., *Populus nigra* L., *Populus alba* L., *Alnus glutinosa* L. (Gaertn.), and *Fraxinus ornus* L. with a dense shrubwood layer composed by *Cornus mas* L., *Crataegus monogyna* Jacq., and *Prunus spinosa* L. (www.inaturalist.org. Accessed on 19.06.2022). Scats were identified based on a conservative multi-criteria approach (Ciucci 1996), they were selected by their shape, content (e.g., rich in hair and bones), size (over 10 cm long and 4 cm wide), position, and characteristic odour (Asa et al. 1985; Ferretti et al. 2019). Collected samples were placed in *ad hoc* plastic bags labelled with the date and georeferenced collection place, then frozen at –20 °C at the National Research Council in Sesto Fiorentino (cf. Ferretti et al. 2019). For the analysis, scats were dried for 3 hours at 80 °C to kill potential parasites harmful to humans, then washed in hot water to separate diet components (mostly hairs). Animal hairs were fixed on glass slides following standard methods (Mori et al. 2016) and observed at a binocular microscope 400× (Olympus BX 51 microscope), analyzing both the cortex structures and the medullar patterns to determine the prey species. Hair structures were compared with a local reference collection of the National Research Council and reference atlas (Paolucci & Bon 2022).

For each prey, we computed the absolute frequency of occurrence (AF%) of each prey species through the ratio between the number of occurrences of each prey species (n_i) and the total number of scats analysed (N):
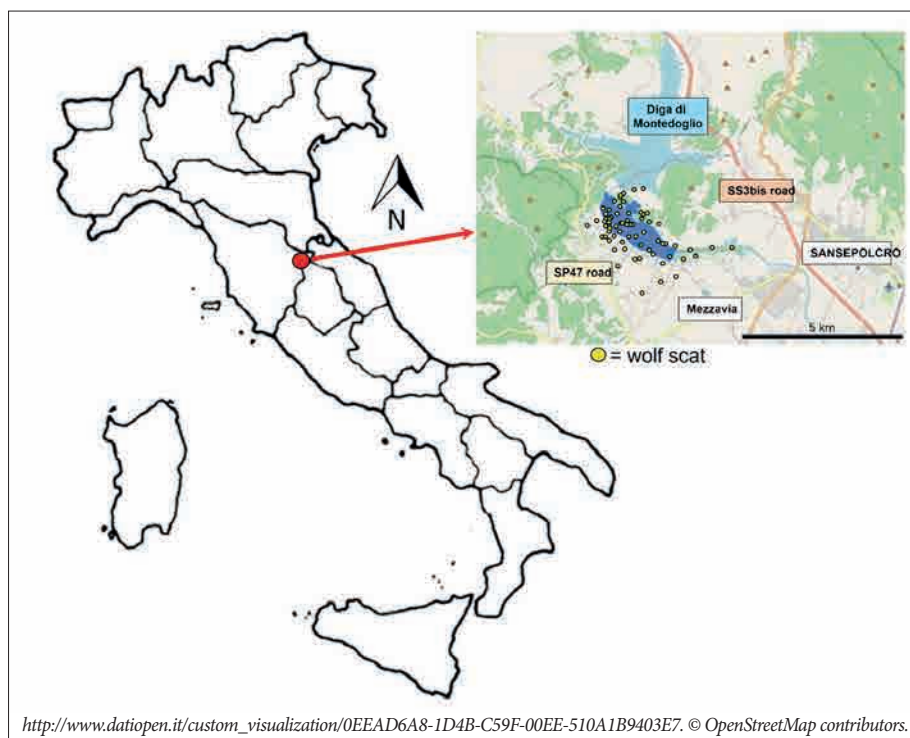
Fig. 1 - *Location of the study area ANPIL Golena del Tevere.*
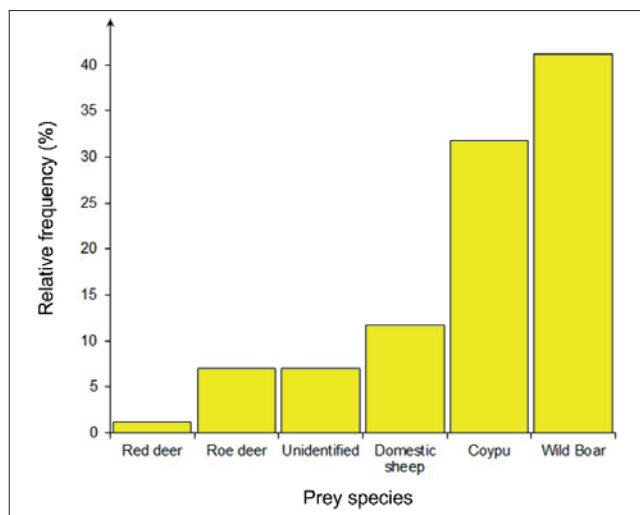- Localizzazione dell'area di studio, ANPIL "Golena del Tevere".

Fig. 2 - *Relative frequency of prey species consumption by the wolf in Area Naturale Protetta di Interesse Locale "Golena del Tevere".*
- *Frequenza relativa delle prede consumate dal lupo presso l'Area Naturale Protetta di Interesse Locale "Golena del Tevere".*

	n items	RF %	AF %	EV %
Red deer	1	1.18	1.45	33.30
Roe deer	6	7.06	8.70	53.90
Unidentified	6	7.06	8.70	10.40
Domestic sheep	10	11.76	14.49	43.10
Coypu	27	31.76	39.13	57.12
Wild Boar	35	41.18	50.72	75.40

Tab. I - *Number of items for each prey species in N = 69 scats, relative frequency (%), absolute frequency (%) and estimated volume (%).*
- *Numero di resti per ogni categoria di prede in N = 69 escrementi di lupo, frequenza relativa (%), frequenza assoluta (%) e volume stimato (%).*

AF% = (n_i / N) × 100. The relative frequency (RF%) was computed through the ratio between the number of occurrences of each prey (n_i) and the total number of occurrences of all categories (N_{tot}): RF% = (n_i / N_{tot}) × 100.

The volume of each consumed prey (when present) was computed as EV% = estimated volume of each prey species estimated by eye/total number of scats × 100. Volumetric methods highlight the importance of each food category in the diet, whereas methods based on frequency show how often each prey species is consumed. Thus, a combination of both methods may provide a general idea of the food habits of the study species. Accordingly, we plotted absolute frequencies and estimated volumes of each species in an isopleth graph (KRUUK & PARISH 1981), to evaluate the total volume of each prey species in the wolf diet.

As to our samples, the Brillouin Diversity Index (BRILLOUIN, 1956) indicated that twenty samples were enough to provide reliable information on the local diet of the wolf (GLEN & DICKMAN 2006). However, it should be noted that 69 samples may still be inadequate for the detection of rare prey species, if any.

Results

In our sample, the wild boar was the most consumed prey species in terms of relative frequency followed by the coypu (Figure 2; Table 1). Also, domestic sheep were an important part of the local diet of the wolf.

Also combining frequency and volumetric methods, wild boar and coypus built up the staple of the diet of the wolf in the study area, representing over the 20% each of the consumed prey species (Figure 3).
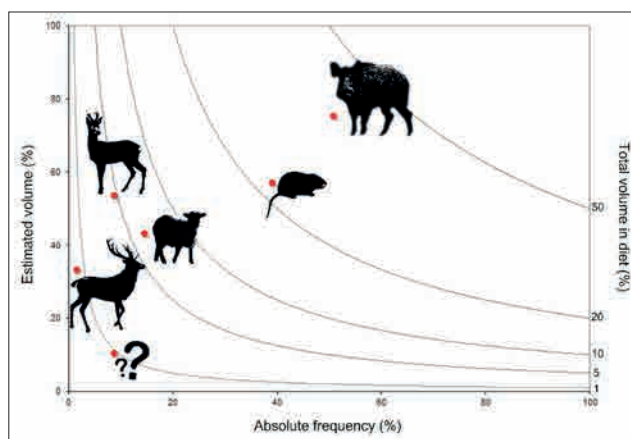

Fig. 3 - *Diet of the wolf (N = 69 scats) in Area Naturale Protetta di Interesse Locale "Golena del Tevere": absolute frequency plotted versus the volume of each food category, when present. Isopleths connect points of the same total volume in diet. The question mark refers to undetermined rests.*
- *Alimentazione del lupo (N = 69 escrementi) nell'Area Naturale Protetta di Interesse Locale "Golena del Tevere": le frequenze assolute sono messe a grafico con i volumi di ogni categoria alimentare, quando presente. Le isoplete uniscono i punti con il medesimo volume totale nella dieta. Il punto interrogativo si riferisce a resti indeterminati.*

Discussion

Our data provide only preliminary information on the food of wolves in coexistence with beavers in Central Italy, to be confirmed by further studies. Seven prey species were identified, including all the wild ungulates present in the study area, the most widespread domestic species (the sheep), and one of the three large rodents present in the study area, i.e. the coypu. Particularly, our results are in line with those from the rest of Italy showing the wild boar as the most consumed prey by the wolf (cf. MORI et al. 2017; FERRETTI et al. 2019), although we lack data

on prey local abundance to determine the local prey selection. The coypu is the second prey for importance. This alien species of South American origin represents easy prey for the wolf, given the low speed of this species and the local high availability (cf. Schertler et al. 2021). Coypus have been anecdotally reported also to represent the main food of the wolf in the Po Plain (Northern Italy), where the availability of wild ungulate is low.

The frequent consumption of domestic sheep in our study area is linked to their high local availability, as represent the commonest farmed species in the study area, with cattle and horses being more abundant in mountains (Alpe della Luna Natural Reserve: Ferretti et al. 2021).

The low consumption of roe deer might be due to the presence of larger cervid species, e.g. red deer Cervus elaphus and fallow deer Dama dama, which may limit its local availability. In the Maremma Regional Park, wolves selected fallow deer which were not detected in scats of our study area.

Differently from our prediction, we did not find any evidence of beaver consumption by the wolf, despite the severe drought which occurred during the sampling year (https://drought.climateservices.it/ Accessed on 31.03.2022). Beavers may still be low in population density (at least one group with 3 or 4 individuals; Pucci et al. 2021; Mori et al. 2021), and the wolf may not have begun to regard them as profitable prey. Therefore, following the recommendation by Gable et al. (2017), our study requires to be repeated in the next year to fully understand wolf-beaver-ungulate dynamics and to preserve these species in line with European and National Directives, possibly integrating also direct observations and metabarcoding analyses on wolf scats.

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Disclosure statement

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