



Why do wolves eat livestock? Factors influencing wolf diet in northern Italy



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ABSTRACT

Thanks to protection by law and increasing habitat restoration, wolves (*Canis lupus*) are currently re-colonizing Europe from the surviving populations of Russia, the Balkan countries, Spain and Italy, raising the need to update conservation strategies. A major conservation issue is to restore connections and gene flow among fragmented populations, thus contrasting the deleterious consequences of isolation. Wolves in Italy are expanding from the Apennines towards the Alps, crossing the Ligurian Mountains (northern Italy) and establishing connections with the Dinaric populations. Wolf expansion is threatened by poaching and incidental killings, mainly due to livestock depredations and conflicts with shepherds, which could limit the establishment of stable populations. Aiming to find out the factors affecting the use of livestock by wolves, in this study we determined the composition of wolf diet in Liguria. We examined 1457 scats collected from 2008 to 2013. Individual scats were genotyped using a non-invasive genetic procedure, and their content was determined using microscopical analyses. Wolves in Liguria consumed mainly wild ungulates (64.4%; in particular wild boar *Sus scrofa* and roe deer *Capreolus capreolus*) and, to a lesser extent, livestock (26.3%; in particular goats *Capra hircus*). We modeled the consumption of livestock using environmental features, wild ungulate community diversity, husbandry characteristics and wolf social organization (stable packs or dispersing individuals). Wolf diet varied according to years and seasons with an overall decrease of livestock and an increase of wild ungulate consumption, but also between packs and dispersing individuals with greater livestock consumption for the latter. The presence of stable packs, instead of dispersing wolves, the adoption of prevention measures on pastures, roe deer abundance, and the percentage of deciduous woods, reduced predation on livestock. Thus, we suggest promoting wild ungulate expansion, the use of prevention tools in pastures, and supporting wolf pack establishment, avoiding lethal control and poaching, to mitigate conflicts between wolf conservation and husbandry.

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1. Introduction

The wolf (*Canis lupus*), because of its adaptability to different environments and its ability to re-colonize territories when no persecution occurs, has in just a few decades expanded its range in Europe (Balciuskas, 2008; Breitenmoser, 1998; Chapron et al., 2003, 2014). The Russian wolf population is the largest in Europe, supporting those of Baltic and North-European countries, and it is contiguous with the

populations of Eastern Europe from which wolves began the re-colonization of Central Europe (Ansorge et al., 2006; Linnell et al., 2005). The Spanish wolf *Canis lupus signatus* (2200–2300 individuals) is slowly extending its distribution (Mech and Boitani, 2003).

Wolves greatly declined in Italy, surviving in two small isolated sub-populations confined to the southern and central part of the Apennines. At their nadir in the early seventies of the last century, wolves in Italy numbered about 100 individuals (Zimen and Boitani, 1975). Since the late eighties, wolves have shown a spontaneous rapid recovery, re-colonizing all the Apennines and reaching the western Italian and French Alps (Boitani, 2000; Breitenmoser, 1998; Fabbri et al., 2007; Marucco and McIntire, 2010; Valière et al., 2003).

The re-colonization of the Alps would be a fundamental step for wolf conservation in Italy and Central Europe as well (Genovesi, 2002). Moreover, the early and ongoing wolf expansion from the eastern

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Alps will predictably increase chances to originate mixed packs and increase the local genetic diversity as has been already described (Fabbri et al., 2014; Randi, 2011).

The sub-population of wolves inhabiting the Liguria region thus plays a crucial role in assuring the linkage between the wolves of central Italy and those of the Western Alps (Fabbri et al., 2007). If this link should break, the wolf population of the Western Alps would be isolated, perhaps failing to recolonize the remaining part of the Alps.

The distribution of wolves is usually determined by the abundance of its preys, environmental characteristics, and the risk associated with the presence of humans (Eggermann et al., 2011; Jędrzejewski et al., 2004; Massolo and Meriggi, 1998). This last point is the key problem of wolf conservation because wolves can have a dramatic impact on livestock breeding, affecting human attitudes that can lead to illegal killing, increasing the risk of extinction (Behdarvand et al., 2014; Kovařík et al., 2014).

The impact of wolves on livestock is different according to geographical region. In regions with a very low abundance of wild ungulates, as in Portugal and Greece, wolves feed mainly on livestock (Migli et al., 2005; Papageorgiou et al., 1994; Vos, 2000). On the other hand, in Germany attacks on livestock are rare because shepherds equip the pastures with electric fences to protect their herds and because the wild ungulate availability is high (Ansoerge et al., 2006).

In other new-recolonizing areas such as France or North Italy, wild ungulates are the main prey of wolves, but the use of livestock is still noticeable (MEEDDAT-MAP, 2008; Meriggi et al., 2011; Milanese et al., 2012).

Systematic research on wolf feeding ecology has been carried out since 1987 in the Ligurian Apennines. These studies showed an increasing use of wild ungulates in the time but also a medium–high use of livestock species as prey (Meriggi et al., 1991, 1996, 2011; Schenone et al., 2004). Consequently, wolf presence in Liguria, as well as in other areas of natural re-colonization, causes a conflict with human populations that perceive predator presence as a negative element that can compromise a poor rural economy. Thus, wolves suffer a high mortality mainly due to illegal killing and accidents. This situation makes the population vulnerable and actions aimed at a greater protection of the species are required.

Usually wolf populations are structured in stable packs and lone wolves; packs are formed by a pair of adults, by their offspring and other related individuals (i.e. the offspring of previous years), and sometime by adopted individuals, whereas lone wolves are erratic individuals that can temporarily establish in an area without packs. In general lone wolves are young dispersing from packs but they can also be adults moving far from their original pack because of pack disruption or break off for several causes (killing by humans, low prey availability and related increasing aggressiveness, natural death of the dominant pair) (Mech and Boitani, 2003). Packs are established in areas with high prey availability, because only a high availability of preferred prey can dampen the aggressiveness of the pack members and avoid pack disruption (Thurber and Peterson, 1993). Dispersing and erratic individuals use the areas without wolf packs that can be considered suboptimal habitats because of the low prey availability, high human disturbance, and possibly potential problems with local people (Fritts and Mech, 1981). Illegal killing can break the packs, increasing erratic wolves and reproductive pairs that can have a greater impact in particular on livestock rearing (Wielgus and Peebles, 2014).

The objective of the present study was to determine which factors influence wolf diet, in particular, the choice of livestock as prey, which is the first step to find solutions for wolf conservation. With this aim, we determined wolf diet, by analyses of scats collected in the whole Liguria region from 2008 to 2013. We highlighted the factors influencing it, i.e. years, seasons, ungulate abundance, and social structure of wolves (packs or dispersing individuals). Then we related livestock consumption to environmental features, wild ungulate abundance and

diversity, husbandry characteristics, wolf grouping and habitat occupancy behavior (stable packs or dispersing individuals).

2. Material and methods

2.1. Study area

This research was carried out in the Liguria region, north Italy (44°30'16", 8°24'10"). The study area spreads over 5343 km² including a part of the Northern Apennines and of the Western Italian Alps, until the border with France. The region is divided in four provinces, Imperia, Savona, Genoa and La Spezia, respectively from the western to the eastern part (Fig. 1). Altitude ranges from 0 to 2153 m a.s.l.; 36% of the area is between 0 and 400 m a.s.l., 35% between 400 and 800 m, 21% between 800 and 1200 m, and 8.5% more than 1200 m a.s.l. Forests cover 63.8% of the region (deciduous woods: 28.8%; conifer woods: 7.1%; mixed woods: 27.9%), pastures 6.2%, agricultural areas 17.1%, and urbanized areas 3.9%. Towns and villages, as well as farmlands, are concentrated on flat terrains, close to the coasts. The climate extends from Mediterranean on the coast to sub-oceanic in the mountains. The temperature extends from −2 °C in winter to 35 °C during summer. Mean annual precipitation ranges from 750 to 1250 mm in the west to 1350–1850 in the central and eastern part of the region. On the ridge of the mountains and in the upper part of the valleys, snow cover can reach more than one meter from November to April.

The wild ungulate community includes wild boar (*Sus scrofa*), widely distributed with high densities (21,500 individuals shot per year in Liguria, on average from 2007 to 2012), roe deer (*Capreolus capreolus*), abundant in particular in the central provinces (30.9 individuals per km² on average from 2009 to 2012). Fallow deer (*Dama dama*), introduced for hunting, is present in the provinces of Genoa and Savona (10.7 and 5.8 individuals per km² respectively). Chamois (*Rupicapra rupicapra*) is present only in the Maritime Alps (927 individuals counted on average from 2007 to 2012), while red deer (*Cervus elaphus*) and mouflon (*Ovis aries musimon*) are very rare in the study area (data from Wildlife Services of Imperia, Savona, Genoa and La Spezia).

This high availability of wild prey promoted a natural recolonization of the region by wolves in the late eighties, starting from the provinces of Genoa and La Spezia (Meriggi et al., 1991, 1996, 2011; Schenone et al., 2004). Now the wolf is present in the four provinces with a minimum population of 58 individuals of which 21 distributed in 5 packs and 37 lone wolves, estimated by genetic analyses (see Results).

Livestock (15,000 cows and 33,900 sheep and goats) are free-grazing on pastures from April to October but the grazing period can be expanded or reduced depending on the weather. Pastures are often partly composed of shrubs and woodlots. Only few shepherds adopt prevention methods (i.e. nocturnal recovery, guardian dogs, and electric fences) to deter wolf attacks.

2.2. Data collection

We divided the study area in 64 isometric cells of 10 × 10 km, as a trade-off between the average territory size of the wolf in Italy (Ciucci et al., 1997; Corsi et al., 1999; Apollonio et al., 2004; Caniglia et al., 2014) and sampling feasibility. In each cell, we randomly chose an itinerary among the existing footpaths according to the Tessellation Stratified Sampling (TSS) method that permits a better distribution and representativeness of the random samples than a simple random design (Barabesi and Fattorini, 2013; Barabesi and Franceschi, 2011). We traced a total of 64 itineraries in the study area (total length = 287.6 km, mean ± SD = 4.5 ± 1.59 km, min. = 2.3, max. = 10.4) that were covered once a season (spring: March to May; summer: June to August; autumn: September to November; winter: December to February), from January 2008 to August 2013 searching for wolf scats and signs of wild ungulate presence (tracks, sightings, rooting,

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