Impact of wolf (Canis lupus) on animal husbandry in an Apennine province

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PAPER

Impact of wolf (*Canis lupus*) on animal husbandry in an Apennine province

Claudia Russo,[1] Silvana Mattiello,[2] Carlo Bibbiani,[1] Alessandro Baglini,[1] Paolo Bongi,[3] Claudia Facchini[3]

[1]Dipartimento di Scienze Veterinarie, Università di Pisa, Italy

[2]Dipartimento di Scienze Veterinarie e Sanità Pubblica, Università di Milano, Italy

[3]Freelance Biologist

Abstract

Predation has always been an important problem in extensive sheep farms, causing serious economic losses to the farmers. In the Province of Lucca, the presence of reproductive wolf packs has already been confirmed in natural reserves, but occasional signs of presence of the predator have been reported also in neighbouring areas. The present research has been carried out in this Province (between the Orecchiella Natural Reserve and the medium Serchio Valley), in order to obtain more complete information on the location of the wolf (with transects, wolf-howling and snow-tracking), and to verify the real impact and risk factors of predation on livestock (by means of on-farm surveys carried out in 42 semi-extensive farms) in this area. The presence of wolf was confirmed in the study area with a minimum of four adult individuals and at least one pup: this pack lives around the peaks of the Apennines in the municipalities covered by this investigation. A growing conflict between the wolf and the sheep and goat farms was observed: since 2007 there have been 25 attacks and three farms can be considered subject to chronic predation. The major risk factors are high altitude, large flock size and lack of fences and of guardian dogs. An accurate knowledge of wolf presence and the identification of the farms mostly at risk can be useful for future planning of interventions aimed at prevention and support of farmers, in order to mitigate the conflict caused by predation.

Introduction

The worldwide status of the wolf (*Canis lupus* L., 1758) has, in recent years, been declared of lower conservation priority due to population stabilization, with the IUCN (International Union of Conservation of Nature) declaring the species at minimum-risk (Least Concern). International Conventions and Directives (Habitats Directive, Bern Convention) and consequent adjustments of national and regional laws, together with the peculiar characteristics of the species, have first allowed a recovery and then a stabilization of the population density of this predator.

The situation in Italy, however, is slightly different. The first protection rules date from the 1970's, and consequently, the Apennine subspecies (*Canis lupus italicus*, Altobello, 1921) still shows a state of fragility (classification: vulnerable), albeit with a positive trend: a taxon that falls into this category is considered to be at high risk of extinction in the wild in the medium and long term. The importance of predators to the ecological balance of the environment has long been known, and thus has been underlined by the Italian Framework Law on the protection of warm-blooded animals, in which it is hoped for carnivores: the preservation of the actual reproductive capabilities and the natural containment of other species (Italian Regulation, 1992).

To manage this ever-expanding population, a monitoring programme has become necessary in the Apennines area. Tuscany shows many mountain ranges, related to both the main backbone chain and the secondary chain. Depending on this strategic location at the heart of the Apennines, and on the quantity and quality of the environments suitable for the survival of the species, the wolf is present throughout the region, with differing densities between provinces (Banti *et al.*, 2005; Mattiello *et al.*, 2012).

In the State Natural Reserve of Orecchiella (Province of Lucca), monitoring has been carried out by the State Forestry Corps since 2002, reporting that an established pack of wolves gravitates around the same reserve and has successfully reproduced (Ragagli *et al.*, 2006). Numerous signs indicating the presence of wolves around the municipality of Minucciano, and the discovery of a dead wolf in 2005, indicate an expansion attempt of the species towards the Piedmont areas. Despite the essential role of wolf as top-predator in the food chain, and its importance for biodiversity conservation, this species has been often pursued, especially in areas where the presence of sheep is higher, due to high predation-related phenomena as a function of the predator population itself (Dupré, 1996; Ciucci and Boitani, 1998). This fact is particularly significant considering that poaching is one of the main factors of mortality at local level. The increased presence of uncontrolled stray dogs in Italy has exacerbated the man-wolf conflict, due to livestock injuries or killings by dogs being erroneously attributed to wolves (Genovesi and Duprè, 2000). Although there is a national law (Italian Regulation, 1991) and some regional laws providing compensation for damage caused by wolves on livestock, Tuscany has decided to give only grants for payment of the insurance (Regional Law 26/2005). As a result, although predation phenomena has been increasing, the official number of complaints has decreased (Mattiello *et al.*, 2012) but, at the same time, unlawful killings continue to be one of the main causes of death, resulting in increased persecution of the wolf.

In order to reduce the wolf-livestock-man conflict and promote a peaceful coexistence, an accurate grasp of the problem with realistic solutions is highly recommended. For particularly elusive species like the wolf, whose presence has strong economic and social implications, it is essential to use any kind of information to provide the government and citizens with substantial answers. The present research has been carried out in the Province of Lucca in order to ascertain the location of the wolf in the province (with transects, wolf-

Corresponding author: Dr. Claudia Russo, Dipartimento di Scienze Veterinarie, Università di Pisa, viale delle Piagge 2, 56124 Pisa, Italy.
Tel. +39.050.2216902 - Fax: +39.050.2216901.
E-mail: crusso@vet.unipi.it

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howling and snow-tracking), and to verify the real impact of predation on livestock, which is often underestimated due to under-reporting of events.

Materials and methods

Study area

The study was conducted between the beginning of June 2011 and the end of May 2012, in Lucca Province, where some cases of predations were registered; in particular, the survey was conducted in the municipalities of Barga (44°04 30 N 10°28 54 E), Pieve Fosciana (44°07 58 N 10°24 43 E) and Fosciandora (44°06 57 N 10°27 34 E), between the Orecchiella State Natural Reserve and the middle valley of the river Serchio. This area, situated between the Apuan Alps and the Tuscan Emilian Apennines, has a surface area of about 110 km^2 and an elevation ranging between 160 and 1000 m asl. Sheep and goat are the main husbandry activities in this area, whereas cattle are present in low numbers and usually only for family use. This area is rich in forests and shows the typical features of the Apennine environment. It is bordered to the north by the Lunigiana, to the West by the Versilia and the province of Massa, to the east by the Emilia-Romagna (Provinces of Modena and Reggio Emilia). The area is entirely crossed by the Serchio River and its tributaries. The municipalities involved, particularly those of Pieve Fosciana and Fosciandora, occupy the portion over the Apennine hills and also portions of the valley floor.

Data collection and analysis

Wolf presence

The first step to determine wolf presence was to gather information on the areas actually utilised by the species itself. Information was obtained using three validated techniques: transects, wolf-howling and snow-tracking, described as follows:

Transects. On the basis of information deriving from historical records, random sightings and reports by non-specialized personnel, we identified three transects representative of the whole sampled area, with an average length of 10,480 km (Figure 1). Each transect was repeated nine times from June to November 2011. The presence of the species along the transects was confirmed by direct sightings of the animals or by indirect signs of their presence, such as footprints, tracks, excrements, feeding marks, scrapes, dens or hairs, as well as carcasses or body parts.

For each identified sign of presence, the coordinates were recorded using GPS. Data comprising date of occurrence, weather, location and deposition substrate were recorded on a field card. Exposure and condition were considered in order to verify new wolf signs during the following transects: excrements found only once in a given point were considered as random passages of the wolf, whereas, if more than one excrement deposition was found at one point, this point was considered a point-marking. As a territorial species, wolves scent mark their territories to communicate their presence (Peters and Mech, 1975; Rothman

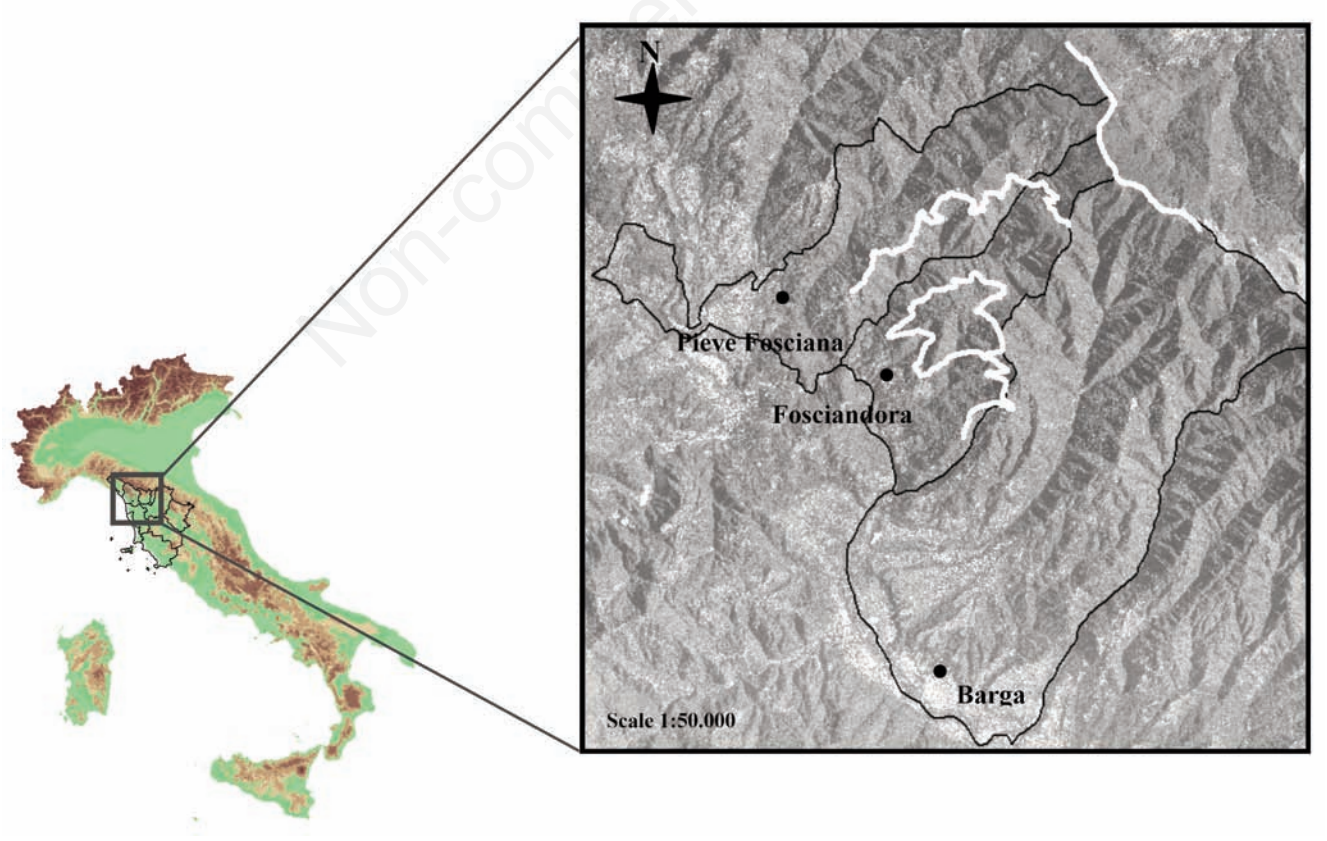

Figure 1. Study area with transect (white line) and boundaries of municipal districts (black line).

and Mech, 1979). The Kilometric Index of Abundance (KAI) was calculated as the ratio of the number of individuals (or of signs of presence) observed along one transect out of the total transect length covered at each site (Preatoni *et al.*, 2012). KAI is a common measure used in wildlife studies because it allows a straightforward comparison of species abundance in different sites or at different times.

Wolf-howling. Within packs, howling serves as a long-distance contact call, facilitating reassembly while among packs and helps residents and intruders to avoid confrontations for maintaining territories (Harrington and Mech, 1979). Wolf-howling consists in stimulating resident wolves to vocalize by using human simulation or a tape-recorded playback of actual wolf howl, and has been used for many decades to estimate wolf number (Joslin, 1967). This method is generally applied during summer period, with some authors also obtaining interesting results during late summer-early autumn and during the mating season (Harrington and Mech, 1979, 1982; Gazzola *et al.*, 2002).

For this study, the record stimulus was a howl produced by a captive wolf pair (duration: 1 min and 40 s). The howls were recorded with a media player, a linear amplifier of 40 watts of power and an exponential horn with high directionality of emission (120° horizontal coverage and 60° vertically). Sampling sites were chosen to maximize the range of audibility and to minimize sound dispersion, and their location and number was such as to completely cover the study area. Nineteen howling sessions were carried out during summer-early autumn for a total of 83 sampling sites and 149 emissions (trials) (Table 1). Each session was a continuous period of 15 min, during which we tried to elicit howling by a maximum of two trials, interspaced by a time of silent listening. If no reply followed to the first playback stimulus, a second trial was attempted five min later, after which the operator left the site. As soon as a response was heard, the session was terminated and the operators moved to contiguous areas. Howling sessions were carried out between dusk and dawn. No trial was performed in presence of wind or in case of precipitations. Replies were recorded on an M-Audio *microtrack* 24/96, using a Sennheiser (mod. K6p) directional microphone and later submitted to acoustic analysis (spectral analysis of the sonograms using the Raven Pro 1.3 software), which allowed identification of the minimum number of howling individuals (Theberge and Falls, 1967; Harrington and Mech, 1979; Tooze *et al.*, 1990). Estimation of age-class (pup/adult) was also possible from these analyses, on the basis of the different frequency range at which adults and pups express their vocalizations and of the length of howl (Harrington and Mech, 1979; Harrington, 1986).

Snow-tracking. Snow-tracking was performed in February during the 24-48 hours following two modest snowfalls, when a layer of fresh snow had formed, allowing accurate location of wolf tracks and the ability to follow them along different pathways. This method of monitoring is fundamental in estimating the minimum pack size. In fact, wolf predator has particular gait, the hind leg rests on the ground exactly in the wake of the front legs, so as to leave only one runway. Individuals in the pack walk in single file in the footsteps of the first individual. Until members of the pack begin to disperse, the track gives the impression of belonging to a single individual (Harrington and Mech, 1979, 1983). Every time the pack disperses in larger areas, it was possible to count the actual number of individuals belonging to the pack. During these investigations, it was also possible to perform the georeferencing of excrement maintained in excellent condition due to the weather conditions.

On-farm surveys

All goats and sheep farms, recruited from the lists of the ASL of Lucca (19 farms in the municipality of Barga, 13 in the municipality of Pieve Fosciana, and 10 in Fosciandora), were initially visited in June and July 2012. Questionnaires were completed relating not only to structural and management characteristics of the farms, but also to specific predation events. In the middle and at the end of the trial (January and May, respectively) farmers were contacted by telephone to determine whether any new cases of predation by wolves had occurred during the examined period. Fisher's exact test was used to compare frequency distributions of farms affected or non-affected by predation depending on the use of summer ranges, on their location (altitude), on farm size (number of animals) and on the presence of vegetation cover.

Results and discussion

Wolf presence

Transects. On all transects, a total of 21 excrements were found. The KAI was 0.121, lower than the findings of Meriggi and Lovari (1996) who calculated a KAI of 0.8 in Liguria Region: unfortunately, this index is scarcely used in Italy and therefore it is not possible to make comparisons with situations similar to that of Tuscany.

Wolf-howling. Wolf-howling did not elicit a response to each stimulus, so it is interesting to assess the sampling effort and the percentage of responses out of the total number of stimuli (Table 1). Due to an unfavourable climate, wolf-howling in this trial was prolonged during the winter months. The maximum effort was produced during August and September, a period in which the wolves have a greater propensity to defend their territories and their pups with acoustic signals. The highest response rate was observed in the January, in spite of the fact that the number of stimuli produced was lower (Table 1). In November one single howling (that could be tracked only by the acoustic analysis of the sonograms) was recorded. This is probably the single howl of a wolf that had temporarily moved from the pack. During January the response of a minimum number of four wolves, including a puppy, were obtained twice.

Snow-tracking. Snowfalls occurred in February, allowing tracks to be monitored in the snow in order to understand the composition of the pack in this area. Only once was a wolf trail found that would enable assessment of group size, estimated at a minimum of four individuals. During tracking, no signs of predation or excreta were found.

On-farm surveys

The general characteristics of the surveyed farms are presented in Table 2. The number of animals bred was generally quite low: in the

Table 1. Sampling effort, number of responses and response rate during sampling.

	August	September	October	November	January
Days, n	5	7	2	3	2
Sampling sites, n	26	34	8	9	6
Stimulus, n	46	62	14	9	11
Response, n	0	0	0	1	2
Response rate	0	0	0	0.11	0.18

case of sheep, 16 farms had less than 50 subjects, while the remaining 12 farms had more animals (up to 120-130 individuals in three farms). The average number of goats raised was significantly lower: 22 farms had less than 50 animals and only a single farm owned 72 subjects. Sometimes flocks were composed of different breeds, indicating a generally low level of specialization. Regarding sheep, the main breeds were Massese and Garfagnina (both pure or crossbred), but the presence of animals not attributable to any specific genetic type was also recorded. Regarding goats, most are not attributable to any genetic type, but in many farms Saanen, Garfagnina and Cashmere animals were raised. Six farms raised sheep and goats together. The main production was meat (47.6% of the farm) and meat and milk (45.2% of the farm) while only two farms exclusively produced milk. Cashmere goats were only used to reduce undergrowth by grazing.

Only six farms (in winter located in the town of Barga) were transhumant (11.9%), and moved to higher altitudes (between 1000 and 1600 m asl) during the summer. The average surface area available for grazing in summer ranges was of 50 hectares (ranging from a minimum of 3 to a maximum of 100 hectares). Vegetation cover, mainly composed by chestnut and beech trees, was scored from 0 (absent) to 3 (abundant). According to this classification, some vegetation cover was always present in the farms: in most cases, it was abundant (29 farms), but sometimes it was medium (seven farms) or scarce (six farms). All summer ranges were located in areas with abundant vegetation cover. With the exception of one case, all farms were family owned. The number of persons involved in the management of the animals ranged from one to three (average of 1.3 persons per farm). The farmers lived on site and at least one operator was always with the flock when it was out for grazing; 40 out of 42 flocks were monitored daily, both during grazing and when they were housed in the evening. Forty out of 42 farms were semi-intensive, since grazing alone did not always cover the nutritional requirements of the animals. In these farms, animals could additionally receive hay (quantities varying between seasons), and sometimes concentrate, while housed in the evening. The two remaining farms were intensively managed, with daily administration of feed indoor: hay was supplied *ad libitum*, while concentrate was given in the morning and in the evening during milking. Day fences were not always present. In summer ranges, only one breeder had a high fence (200 cm), with a large rectangular mesh (15x20 cm), deeply anchored to the ground. The other farmers did not always protect grazing animals (45.2%). Fence characteristics were as follows: average height=130 cm (100 cm min; 200 cm max); the mesh in 12/19 cases was rhomboid (4x4), in five cases rectangular (15x20) and in only two cases it was welded; 7/19 fences were anchored to the ground and, of these seven, only three were really deeply anchored.

In summer ranges, only one farm used a fence for the night (200 cm high, with narrow mesh, deeply anchored into the ground), which allowed the animals to graze at night, during cooler hours. No fences were electrified. With the exception of the farm with the night fence, all the other farmers had shelters where the animals spent the night. Thirty-five of 41 shelters were closed and only six were composed of a bare roof. Shelter dimensions ranged from a minimum of 12 m^2 to a maximum of 360 m^2 (average=101 m^2). Therefore, the average space available per animal was approximately equal to one m^2, which can be considered an adequate value to confine small ruminants at night (Loynes, 1983), a practice that is in fact carried out by all farmers. In addition, shelters were also used seasonally for milking and in case of bad weather. This situation is different from the one observed in the study conducted in Val di Cecina (Province of Pisa): in this area, the nocturnal confinement of animals in shelters was considered impossible during the summer, because animals could not graze during the hot hours of the day. Farmers in the Pisa area preferred to have fixed or movable electric fences for protecting small areas of pasture where the animals could graze during the night. However, this practice may lead to higher incidence of parasitic infestations, due to high concentration of many animals in small areas (Garippa, 2006).

Twenty-nine farms had working dogs: twenty-four farms had herding dogs, four had guardian dogs and only one farm owned both kind of dogs. The total number of dogs in the visited farms was 54, including 44 crossbreeds, 5 Maremmano, 4 German Shepherd and 1 Abruzzese dogs. In 28 of 29 farms, dogs were always kept with livestock.

Presence of wolves in the area

Some questions were asked to determine whether the wolf was present in the area under investigation. The responses were very different depending on the altitude of the farms. Belief that the wolf was not present in the area was reported in 24/42 farms (57.17%), located at altitudes below 500 m asl. On the contrary, those located at higher altitudes reported sightings of wolves (n=12, 28.58%) or presumed wolf presence (6/42, 14.25%), based on the discovery of signs attributable to the species or animal carcasses allegedly preyed upon by wolves and not by groups of stray dogs, almost entirely absent in the area.

Regarding the signs of wolf presence near the farms, all breeders who kept all the animals at pasture, as well as 10 farmers who did not keep animals at pasture, reported direct wolf sightings. None, however, ever found dead wolves and only 14 farmers found some signs attributable to the predator (excrements, footprints, carcasses of preyed animals). Seventeen farmers (40.5%) believe that the wolf is a problem for their own farms because they were subject to predation events. When asked what measures are necessary to solve the problem, 64.7% (11/17) of farmers believed it was important to revise the current legislation on the protection of livestock subject to predation. This may ensure fair compensation for the lost animals and for indirect losses such as abortions and loss of production due to stress caused by the attacks, even if these two parameters are difficult to quantify. Of these 11 farmers, however, only nine were familiar with the current laws. Twelve out of 17 (70.6%) farmers believe it is important to provide economic support for implementing defence measures, such as fences against wolves, while only five farmers consider it would be more appropriate to capture wolves and move them to areas without farming activities. Six of

Table 2. General characteristics of the surveyed farms (n=42).

	Minimum	Maximum	Mean	SD
Altitude, m asl	160	1000	585.1	257.5
Total hectares	0	1000	44.5	152.2
Pasture hectares	0	50	9.8	10.9
Sheep, n	4	130	51.2	37.8
Animals°, n	4	147	46.9	40.1
Stockmen, n	1	3	1.4	0.6

SD, standard deviation. °Including sheep and goats.

17 farmers (35.3%) believe that the only decisive solution to the problem is to kill the wolf, thus eliminating it from the territory.

These results show a different attitude from that observed in previous surveys both in Italy and abroad: in general, farmers prefer to improve the system of economic compensation rather than prevention works, which could change traditional farming systems (Weber, 2000; Banti *et al.*, 2005; Caporioni and Teofili, 2005; Mattiello *et al.*, 2010). Ten farmers (all located at an average altitude of 850 m asl) were insured against predation risks, and nine declared that the wolf was in fact a problem. Despite the presence of, on average, two guardian dogs, on eight farms there were cases of predation. Predation was considered the main cause of mortality only on 10/42 farms (23.8%). This result is in line with the findings of other authors, who believe that, in terms of mortality, predation by wolves is less important than other causes (Ciucci and Boitani, 1998). The other causes of mortality reported by the visited farmers were: birth (identified as the leading cause of death in 4.6% of the flocks), trauma (2.4%) and other causes not specifically identified by the farmer (69.2%).

Incidence and characteristics of predation

All municipalities were affected by predation, but the most affected farms were those at higher altitude or those that made use of mountain summer ranges: the lowest predation event was recorded at 600 m asl and the highest at 1600 m asl. Thirteen of 42 farms showed no cases of predation and only three farms (7.1%) were chronically affected by the phenomenon, with at least two attacks per year. On the basis of the memory of farmers, it was not possible to collect accurate information about attacks that occurred before 2007. After this date, it seems that there is a gradual increase in attacks reported by farmers: one during 2007, one during 2008, three during 2009, three during 2010 and 17 in 2011, totalling 25 attacks. On these 25 individual attacks occurred after 2007, detailed data were collected, in order to analyse the characteristics of predation. Although the predator could not always be identified for certain, most of predation events (22/25, 88%) were attributed to wolves. In 18 cases this attribution was confirmed by veterinary inspection, and in two cases predation occurred during daytime, in the presence of the farmer. The presence of stray dogs has never been reported in the area, and this seems to further support the idea that wolves are responsible for predation. The official complaint was made only by 16 farmers, since the remaining two had no insurance. This suggests that the number of events is higher than the official complaints: some attacks are not reported, and the animals are simply declared dead. This can be explained by the lack of insurance coverage due to failure of the farmers to understand the new laws of Tuscany and the complex bureaucratic rules and by the high cost of insurance coverage, which often does not reimburse the true value of the animal and does not compensate for missing animals.

The characteristics described below refer to the 25 individual attacks on livestock that were attributed to wolf predation (either suspected or known). The average number of sheep killed or attacked is 2.86, with a maximum of six and a minimum of one. Only in one case, four sheep carcasses were not found and were considered missing (four animals in a single attack). No cases of surplus killing were registered. Most attacks occurred on sheep, whereas goats were attacked in only two cases, respectively with one and two animals killed. The number of animals killed per attack was 2.55. This is similar to the average value reported by Ciucci and Boitani (1998), but lower than that observed in other provinces of Tuscany: in Pisa province, for example, the average number of sheep killed during each wolf attack was 7.05, with several surplus killing events (Mattiello *et al.*, 2012), while in the province of Arezzo it was 15 (Gazzola *et al.*, 2008). The adult age class suffers more attacks, in agreement with data reported by other authors (Ciucci and Boitani, 1998; Mattiello *et al.*, 2012). In this study, the killing of approximately 10 lambs in 2010 and 10 in 2011 occurred, but these losses were not formally complained, because these young lambs (less than six months old) had not been identified with ear tags yet.

Seasonality of events

The peak time of the attacks was recorded in summer, with 17 reported attacks between June and September. This can be explained by the fact that the farms most affected were those with animals at mountain pastures, where predation risk was higher, whereas in winter almost all farms are at lower altitudes, where the presence of wolves is scarce. The high predation of sheep during summer may be explained by the lowest accessibility of wild prey, due to the growth of their young (Ciucci *et al.*, 2005).

Unfortunately, most of the farmers (17/25) did not remember if the attacks occurred during the day or during the night: seven farmers stated that the attacks took place during the day and only one farmer reported that the attack took place during the night. This is not in agreement with the predatory habits of the wolf (Ciucci and Boitani, 1998), but it may be explained by the fact that, in this area of Tuscany, the animals are always in shelters during the night, which makes them particularly protected from predators.

Risk factors

We tried to understand which were the main risk factors of predation in terms of environment and management, paying particular attention to the three farms which suffered chronic predation. The use of mountain pasture during the summer was one of the main risk factor: predation occurred in 40% of visited farms and in 83% of the summer ranges ($P<0.05$). This confirms previous findings by Russo *et al.* (2012) in the province of Savona, where 75% of summer ranges were affected by predation, while the problem occurred in only 9% of farms located at the bottom of the valley. Among the risk factors, altitude was also critical: only 4.5% of the farms located at an altitude below 600 m asl were subjected to predation, whereas 60% of the farms at altitudes ≥600 m asl had predation events ($P<0.001$); all the three farms with chronic predation were located at heights ranging between 700 and 1000 m asl.

The three farms with chronic predation did not make use of fences during the day or night. However, one farm was equipped with fences, but had no shelters, while the other two possessed closed shelters that were always used for the night, explaining the fact that many attacks occurred during the day. This suggests that the presence of closed shelters for the night or fences is extremely important: this drastically reduces attacks by wolves, even if some attacks happen during the day. Confirming the results of previous studies conducted both in Italy and abroad (Cozza *et al.*, 1996; Mech *et al.*, 2000; Mattiello *et al.*, 2012), our results suggest that the size of the flock is another important risk factor. In fact, predation occurred with significantly higher frequency in smaller farms (5.9% of farms with less than 25 animals *vs* 48% of the farms with more than 25 animals; $P<0.01$) and two farms with chronic predation had more than 100 animals. The susceptibility to attacks of larger flocks can be explained in part by the difficulty of monitoring the large number of animals by the farmer, who usually works alone, or because in these flocks guardian dogs are often numerically insufficient to prevent the attacks (Cozza *et al.*, 1996; Mech *et al*., 2000; Mattiello *et al.*, 2012).

The presence of thick vegetation cover is a commonly reported risk factor (Cozza *et al.*,

1996; Mattiello *et al*., 2010). A comparison between farms with abundant vegetation cover (n=29) and farms with medium/scarce vegetation cover (n=13) confirmed that the risk of predation was higher when the cover was more abundant (41.4% of farms with abundant cover *vs* 7.7% of farms with scarce/medium cover; P<0.05). Another commonly reported risk factor is the distance from human settlements (Mech *et al*., 2000). However, in our case, all the farmers lived on site and the attacks were carried out around their own property.

Efficacy of preventive measures

The degree of association between the presence of defence systems on farms and the incidence of predation was investigated. In our study area, prevention was essentially carried out with night shelters, which were present in all farms except for one that had a night fence: both shelters and fences were used regularly and this may explain why many attacks occurred during the day and not at night, as it would be expected. The farmers are therefore satisfied with this type of protection. In the studied area, none of the fences used for the night were electrified. The farmers are not favourable to these structures, mainly because of the high cost of installation, but also because of subsequent maintenance costs, consisting essentially of cutting the grass. This *phenomenon* was also observed in the provinces of Pisa and Florence (Berzi *et al.,* 2008; Mattiello *et al*., 2012), where many farmers have rejected the adoption of these fences, in spite of the possibility of having them for free.

As previously pointed out, approximately 69% of farms had dogs, but only five were guardian dogs. It is interesting to note, however, that of the three farms with chronic predation one did not have dogs, one owned only one purebred Maremmano dog for a total of about 150 sheep and the third farm had two herding dogs for 126 sheep. So, in only one case, there was a guardian dog in optimal ratio with the animals of the flock: according to literature, it is considered sufficient one dog every 100-150 sheep (Dalmasso, 2003), or a minimum of two dogs and one more each 50 sheep (Stoynov, 2005). The absence of dogs on farms with chronic predation is different from the results obtained in the Province of Pisa (Mattiello *et al*., 2012) and in the Mercantour Park (French Alps) (Espuno *et al*., 2004). In this latter case, the authors suggest that farmers do not use guardian dogs as real preventive system, but tend to acquire them only after the attacks on their flocks. The episodes of predation registered in the Province of Lucca, however, are quite recent, and therefore it is possible that not all famers have already started to adopt preventive measures to solve the problem.

Conclusions

This research was carried out in the towns of Pieve a Fosciana, Fosciandora and Barga (Lucca Province) as there are no previous surveys in this area, although there were repeated reports of damage to domestic livestock, attributed to the wolf. The monitoring of the presence of wolves in this area was carried out with different methods and has confirmed the presence of the species in the study area. Wolf-howling and snow-tracking allowed to estimate a minimum of four adult individuals and at least one pup: this pack lives around the peaks of the Apennines in the municipalities covered by this investigation. Nevertheless, biological and ethological characteristics of the species suggest that the wolf is constantly moving in the territory, as confirmed by the recorded attacks on domestic livestock.

Due to the unfavourable weather conditions during the monitoring period and to the limited investigated surface area, it was not possible to describe the spatial distribution of the pack, but it is plausible to think that this pack moves within Garfagnana, probably even expanding to the province of Massa-Carrara. It is also reasonable that these individuals do not enter the Orecchiella Park, already occupied by another pack that has been monitored for many years. It would be useful to have genetic data to confirm the number of individuals of the pack, their relationships and the possible hybridization with dogs in order to verify the boundaries of the area used by the pack identified in our study area, by comparison with the data collected during other researches. This study showed the existence of a growing conflict between the wolf and the sheep and goat farms located in the study area. Since 2007 there have been 25 attacks and three farms can be considered subject to chronic predation. The wolf is considered a problem only by farmers who live at high altitude, independently of whether they have already been attacked or not; the presence of the predator is ascertained, because all episodes of predation were verified by the veterinarian of the Local Health Unit, so the wolf is considered a growing threat for farming activities. The evaluation of the economic losses suffered by the farmers as a result of wolf attacks, based only on the direct quantification of damages in terms of animals preyed, is not considered exhaustive. Analysis of the economic impact of predation on sheep and goats must take into account the indirect losses resulting from the attacks, due to the stress suffered by the animals - represented by abortions, decreased food intake, reduced fertility and loss of milk production, but these aspects are scarcely quantified. The knowledge of the spatial distribution of the phenomenon and the identification of the farms most at risk are essential to the planning of interventions aimed at prevention and support of farmers, in order to mitigate the conflict caused by predation. Currently, the problem seems to affect mainly farms located at high altitudes, where the forest is abundant, favouring wolf attacks. Predation occurs almost exclusively during the day and mainly during the summer period, with a peak in September, and involves mainly adult animals without cases of surplus killing.

All episodes of predation were also confirmed by the Local Health Unit, both because most of the farmers are insured and, above all, because they have excellent interpersonal relationships with the veterinarians. Surely, because the interviews of the present survey were made in respect of anonymity, the risk of under-reporting of the events of predation was minimum and this permits to obtain a reliable estimate of the entity of the phenomenon. Nevertheless, this methodology has some limits: for detailed information about the attacks, we had to rely on the memory of respondents, which often proved to be unreliable, particularly regarding the hours of the attacks.

It is possible that some old predation events were not reported and therefore the perfect reconstruction and temporal evolution of the phenomenon is not possible, although the tendency for expansion is evident. This survey can be considered as a mere photography of the current state of predation. For an assessment of its dynamics and evolution, as well as of the changes associated with the introduction of preventive measures on farms, it would be fundamental to continuously monitor the situation in the future.

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