Research

FENCING TO PROTECT CATTLE FROM WOLVES IN PORTUGAL

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1. Introduction

Damage to livestock caused by wolves (*Canis lupus*) has been one of the most common impediments to their acceptance by rural communities. Persecution of the wolf in response to its impact on livestock caused the species to disappear from some regions which, in turn, led to the gradual abandonment of traditional husbandry such as shepherding and night confinement in favour of open-range grazing. Unprotected livestock is vulnerable to predators recolonising their former range (Chapron et al., 2014). When there are no adequate mitigation systems in place, retaliatory killings may follow livestock losses and are one of the most important factors hindering wolf survival and recovery (Liberg et al., 2012).

Non-lethal damage prevention measures are often promoted with the aim of reducing conflicts and thus increasing acceptance of wolf presence. General recommendations include shepherding, predator-proof fences, particularly mobile or permanent electric fences, night confinement and livestock guarding dogs (e.g. Boitani, 2000; Linnell and Cretois, 2018). Their use typically requires considerable investment by farmers, not only financial but also in terms of the effort to implement and maintain them in good condition and to make associated changes in husbandry practices. For this to be worthwhile, measures must be effective and efficient.

Assessing the efficacy of damage prevention measures is important to inform future recommendations on their use by farmers and validating them as relevant within wolf conservation actions, but also to establish trust in the measures and in the entities proposing them. Furthermore, it is also important to transmit reliable information on expected costs and possible problems as well as their potential advantages in order to avoid frustration and mistrust that may undermine efforts towards coexistence with wolves.

In Portugal, wolves have been strictly protected by national law since 1988, but the species is still endangered (Fig. 1). The population is stable overall, with recolonisation in some regions offset by reduction in numbers elsewhere (Álvares et al., 2015). It is divided into two nuclei: one north of the Douro River which is more stable and connected with the Spanish population and the other south of the river which is more fragmented and isolated (Pimenta et al., 2005).

Fig. 1 The Iberian wolf has been fully protected in Portugal since 1988 but is still endangered. *(Photo: Diana Barreto / Grupo Lobo)*

The latter was the focus of the LIFE MedWolf project (LIFE11 NAT/IT/069), implemented in 2012–2017 in Portugal and the Province of Grosseto, Italy (see Salvatori et al., 2021 in *CDPnews* issue 21). Its goal was to decrease the impact of the wolf on livestock in areas where the cultural tradition of coexistence with predators had been lost. In this article, we focus on Portugal.

A survey conducted within the project in 2016 in the Guarda and Castelo Branco districts found a 6-fold range expansion of wolves in the region since the last national survey in 2002/03. The presence of two packs was confirmed with a third considered probable, compared to only two probable packs in 2002/03, and a minimum density of 1.42 wolves/100 km^2 (Palacios et al., 2017; Pimenta et al, 2005). Although there have not been any studies of their diet, wolves in this area seem to be highly dependent on livestock for food, probably due to a scarcity of wild prey and high densities and availability of livestock (Álvares et al., 2015). An analysis of official damage records conducted within the MedWolf project revealed that from 2012 to 2016 a total of 449 predation events occurred resulting in 1,213 animals killed, wounded or missing (Palacios et al., 2017). Attacks were more frequent in the northern part of the project area. The highest number (149) occurred in 2014 and the lowest (65) in 2016. Most attacks were on cattle (50%) or sheep/goats (34%), with fewer on donkeys (9%) or ostriches (7%) (Fig. 2). However, sheep/goats (69%) were most often killed/injured/missing as a result of attacks, followed by cattle (24%). The average number of animals affected per attack was highest for sheep/goats (5.8), followed by ostriches (1.5), cattle (1.4) and donkeys (1.1).

Compensation for losses caused by wolves has been available throughout the wolf range in Portugal for 30 years. Payment is conditional on the use of

Fig. 2 Wolves preyed on ostriches at one farm in the project area, causing high economic losses. *(Photos: Grupo Lobo)*

prevention measures. An analysis of damage records in the intervention area carried out at the start of the project showed that shepherds were rarely present at the time of attacks and in 92 % of cases where information was available livestock was unattended (Andrade et al., 2014). Where shepherds were present, they were accompanying goat and/or sheep flocks (Fig. 3). Furthermore, livestock guarding dogs (LGDs) were not present during most predation events (71 %) where information was available. Livestock was insufficiently protected, especially at night, being left in fenced pastures permeable to wolves. We therefore identified improvements to night confinement as having the greatest potential to reduce predation.

Within the LIFE MedWolf project, we planned to implement electric and permanent metal fences with the aim of reducing losses to wolves of extensively grazed cattle and sheep. Farmers in the Portuguese project area expressed little interest in electric fences: they were perceived to be less effective at preventing damage in larger pastures (tens of hectares), which are common in the project area, and requiring extra work for regular maintenance. Permanent, non-electric metal fences, on the other hand, were regarded more favourably for fencing smaller areas to confine livestock in specific situations (e.g. night confinement, during calving/lambing) and were implemented within the project mainly to protect cattle, although some sheep flocks and one ostrich farm were also included. Here, we present our main findings and assess the advantages and disadvantages of the methods used.

2. Intervention area

The project area was in the centre of Portugal, bordering Spain and south of the Douro River (Fig. 4). It consists of a plateau (elevations of 300–900 m) with Mediterranean habitats composed of mixed oak forests and shrubs. The humanised landscape consists mainly of agricultural patches interspersed with forested areas and small scattered villages. It covers seven municipalities and includes four protected areas[1], one Natura 2000 site (Malcata) and one private natural reserve (Faia Brava). It is characterised by a low human population density, with an average of 18.8 inhabitants/km^2 (INE, 2013), where farming and husbandry are the main economic activities.

Cattle, sheep and goat flocks, raised for meat production, are grazed in large areas that include pastures, brush and forest patches. These are typically fenced for confinement purposes using 1–1.2 m high wire mesh or 4–5 strands of barbed wire or, sometimes, a single electrified wire (Fig. 5). Shepherds, LGDs and night confinement are rarely used. Livestock, especially cattle, may be kept in pastures year-round, including during calving (Fig. 5). Farmers usually visit their livestock once a day, checking for new-borns

[1] International Douro Natural Park, Estrela Mountain Natural Park, Malcata Mountain Natural Reserve, International Tejo Natural Park.

Fig. 3 Shepherds and livestock guarding dogs accompanied some sheep/goat flocks but were not common in the project area. *(Photos: Clara Espírito-Santo, Grupo Lobo)*

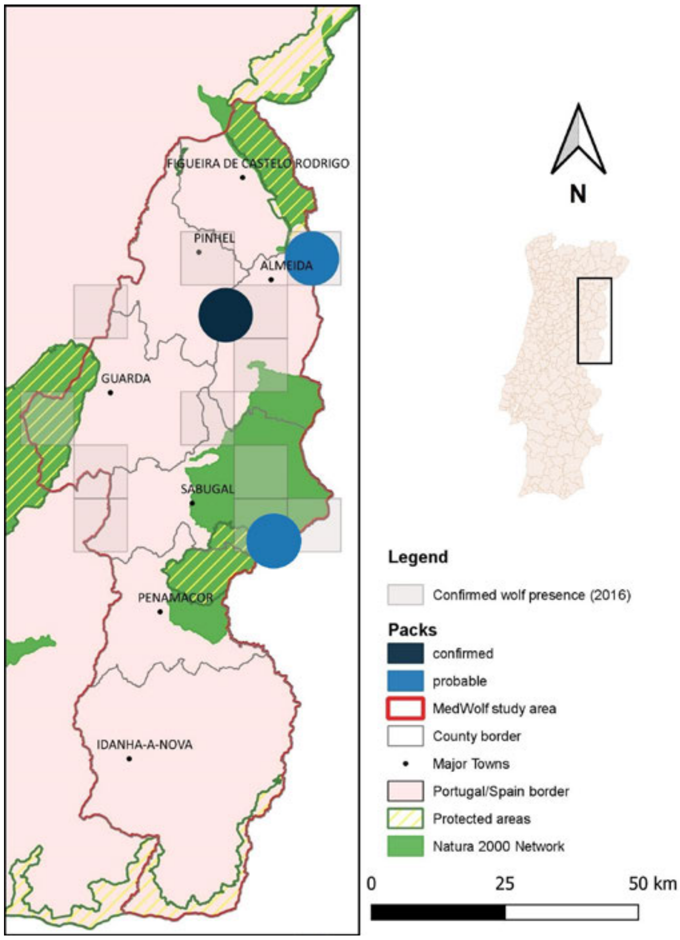

Fig. 4 Location of the project area showing municipalities, wolf range and packs in 2016 (Source: Palacios et al., 2017).

and any problems as well as providing additional food or water if necessary.

Within the project, an initial survey was conducted of 50 farmers with reported damages during the preceding six years or in high-risk areas. Information on wolf damage was provided by the national entity that manages this issue (ICNF). High-risk areas were considered to be those within confirmed wolf pack territories. Cattle herds ranged from four to 100 head (mean = 36) and goats/sheep were kept in flocks of between five and 600 animals (mean = 79) (Andrade et al., 2014). There was also an ostrich farm with 70 animals. Around 44% of farms kept from one to 34 horses or donkeys (mean = 4.5), which were used mainly for breeding or leisure. The average size of farms was 256 ha, with most (60%) in the range 40–320 ha.

Wild prey occurred at low densities, mostly outside the wolf range. Estimated densities of wild boar (*Sus scrofa*) ranged from zero in the north to 1.7 inds./km^2 in the south (Bosch et al., 2012). Red deer (*Cervus elaphus*) were expanding in the southern part, having reached the central area in 2009, and roe deer (*Capreolus capreolus*) were recorded in northern and central areas at the end of the 20th century (Salazar, 2009). Wild ungulate numbers seem to be increasing but this has not been systematically evaluated.

According to the national agriculture census, numbers of sheep and goats in the wider region decreased by 32% and 51%, respectively, whereas the number of cows increased by 12% from 1999 to 2009 (INE, 2011). The average number of sheep (67.4) and goats (10.7) per farm was fairly stable during this period but the number of cows increased from 8.8 to 30 head per farm. In 2009, there were around 61,800 cattle and 425,400 sheep/goats with a total livestock density of 41 head/km^2, far higher than that of wild ungulates.

Fig. 5 Free-ranging cattle are grazed year-round in large pastures with permeable fences that leave them vulnerable to wolves.

(Photos: Grupo Lobo)

3. Methods

In the extensive system of livestock grazing common in the project area, fencing all the pastures was considered unfeasible for ecological and financial reasons, so efforts were focused on identifying and securing the most vulnerable situations. Fences were built to protect calving cows, newborn/young livestock during the day or night or the entire herd/flock at night. The project donated fencing material (metal wire/mesh and poles) at an average cost of €3,500 per farm and farmers were responsible for building the fences and providing gates, with technical support from project staff.

This collaborative approach maximised the number of farmers that could be supported from the available budget and helped ensure that farmers were involved in the process and took responsibility for proper use and maintenance of fences. Participating farmers signed an agreement in which they undertook to comply with project guidelines for fence construction and obtaining necessary licenses, maintaining fences, informing project staff of any problems and allowing them to conduct on-site monitoring.

3.1. Farm selection

Farms were included in the project based on the following criteria: i) they had experienced wolf damage; ii) farmers were committed to long-term operation; iii) farmers were motivated to use fences; iv) farms with cows and sheep were prioritised; v) the terrain was considered suitable for fence construction; vi) included farms had a minimum size of 5 ha and 10 livestock units (LSU). We used data from the initial survey to identify potentially suitable farms which were then visited to conduct an ad-hoc questionnaire survey.

3.2. Fence design and construction

The specific characteristics and site of each fence were adapted to individual farm context and needs. However, all fences were made of welded iron mesh

Fig. 6 Fencing to protect sheep and cattle from wolves, constructed from iron mesh welded panels, cement and granite poles and a concrete plinth under the gates to prevent digging. *(Photos: Dario Petrucci, Grupo Lobo)*

Fig. 7 Chain-link mesh fence at an ostrich farm with cement poles and concrete (masonry) base to prevent digging. *(Photos: ESACB, Grupo Lobo)*

panels (15 × 15 cm mesh for cows, 10 × 10 cm for sheep) with a height of 200–220 cm plus 20–40 cm buried underground. Poles were made of iron, cement or granite. A concrete or rock plinth was placed beneath iron gates to prevent digging (Fig. 6). The ostrich farm had irregular terrain, so a more malleable material was used: chain-link with 10 × 10 cm mesh. The bottom of this fence was concreted to prevent digging and in some places was topped with barbered wire and an outward-facing overhang (Fig. 7).

A total of 34 fences (1–3 per farm) were built at 19 farms, mostly in Almeida municipality (Fig. 8). The first fences started to be built in 2013 and most were finished in 2015. On average, they enclosed an area of 12,509 m^2 with a perimeter length of 390 m (Table 1).

3.3. Assessment of efficacy

The efficacy of project fences was assessed in three ways: 1) a before/after analysis of damage levels; 2) comparison of damage at farms with fences (treatment) versus neighbouring farms without; and 3) ratings of user satisfaction. To compare levels of damage, we used official records, i.e. compensation claims made by farmers and verified by wardens via site visits. For treatment farms/herds, damage that occurred within fences or in pastures near fences where livestock could have been confined was included in the analysis. Fences were monitored to ensure they were properly used and maintained and that husbandry practices did not change.

A total of 22 fences at 16 farms (11 cattle, four sheep, one ostrich) were included in the before/after analysis. This analysis was done in 2014–2016 and did not include fences that were only recently completed at the end of this period. As the date of completion varied among fences, we defined the "before" period separately for each fence as the number of months during which damage was monitored before the fence was completed (mean = 23 months/fence, 31 months/farm) and then summed this for all fences combined (total = 499 months). Similarly, the duration of the after "period", when fences were in use, was calculated for each fence separately (mean = 13 months/fence, 19 months/farm) and summed for all fences across all fences combined (total = 306 months). For each period, the total number of attacks and total livestock killed, injured or missing were summed for all fences combined and then averaged to obtain values per farm and per month.

For the second comparison, we considered 26 project fences (18 for cattle and eight for sheep) at 15 farms that were in operation throughout the period from September 2016 to September 2017. The ostrich farm was excluded from this analysis since there was no other ostrich farm nearby. Neighbouring farms were all those that i) had the same livestock species as the nearest project farm; ii) reported damage during the observation period; and iii) were within 7.7 km of a project fence. This distance was based on the average radius of a wolf pack territory, whose size (mean = 185 km^2) was estimated by telemetry studies in the region (Álvares et al., 2015). Total livestock damage that occurred during the period of analysis was compared at project farms versus neighbouring farms. A period of one year was considered to account for the annual grazing movements of livestock and for wolf bio-ecological dynamics that might have influenced predation rates.

At the end of the project, participating farmers involved in the neighbouring farm analysis were asked to rate their level of satisfaction with the fences using

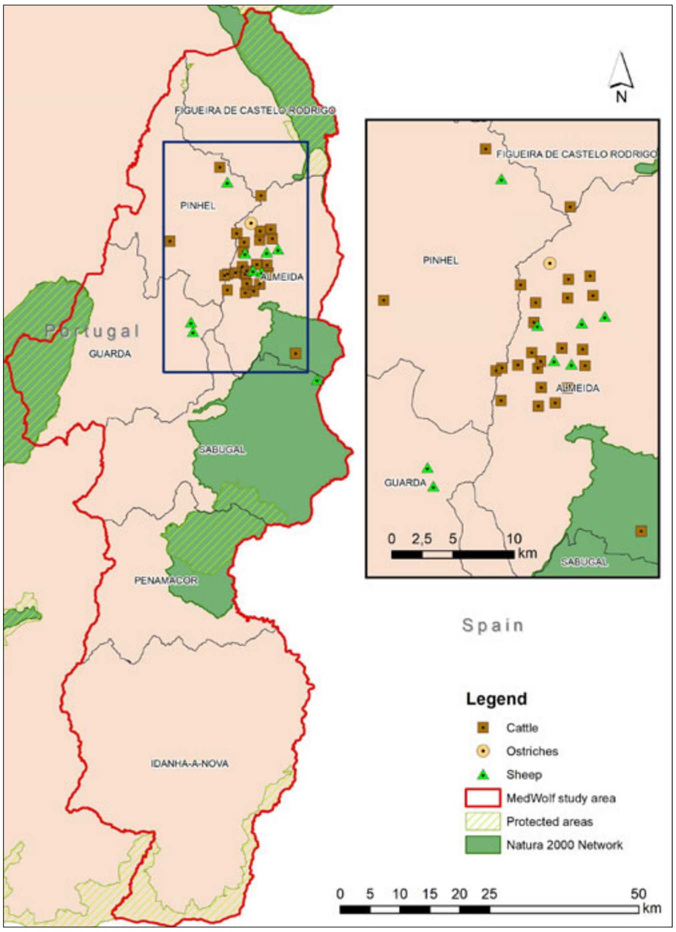

Fig. 8 Location of project fences in relation to municipalities and protected areas.

Table 1 Numbers and characteristics of farms, livestock and fences included in the project.

Farm		Livestock (head)			Fences		
Type	**n**	**Range/farm**	**Mean/herd**	**Total**	**n**	**Perimeter (m)**	**Area (m^2)**
Cattle	12	30–600	173	2,044	24	80–1,160	400–54,000
Sheep	6	32–320	147	881	9	60–400	240–8,400
Ostriches	1	26	26	26	1	1,370	63,770
Total	19	–	–	2,951	34	13,260	425,306
Average	–	–	137	–	–	390	12,509

a four-point scale, from 'very satisfied' to 'not at all satisfied'. They were also asked to describe any problems or advantages they may have experienced while using them.

4. Results

There were no attacks by wolves on cattle or sheep within completed fences and no attempted entry (digging) was detected. At the ostrich farm, three adult birds were killed in one attack 18 months after the fence was completed. This was probably due to terrain irregularity outside the fence, that enabled a wolf to jump over the fence. Following this incident, the fence was immediately improved by raising its height in some sections by 50 cm or adding extra strands of barbed wire and no further attacks occurred during the subsequent 27 months until the end of the project.

4.1. Before / after analysis

The number of wolf attacks on livestock and the number of livestock affected were both substantially lower after fences were constructed compared to the period before. There was an 83% reduction in the average number of attacks per month and an 88% decrease in the average number of livestock killed, injured or missing per month (Table 2).

Table 2 Comparison of damage before and after fence construction at 16 farms.

Number of wolf attacks	Before	After
Total across all farms	119	11
Mean / farm	7.44	0.69
Mean / month	0.24	0.04
Livestock killed/injured/missing		
Total across all farms	210	14
Mean / farm	13.13	0.88
Mean / month	0.42	0.05

4.2. Comparison with neighbouring farms

Throughout the one-year monitoring period, only one project farm (with two fences) was impacted by wolf predation, with a total of 12 sheep killed, one injured and seven missing as a result of five attacks. At least three of the attacks occurred when the flock was left outside the fence at night instead of being confined within it. Wolves caused significantly more damage at neighbouring farms without project fences ($Z = -3.77$, $p < 0.001$). On average, eight cattle and one sheep farm within 7.7 km of each project fence registered wolf damage during the monitoring period affecting a total of 200 head (139 cattle, 61 sheep).

4.3. Farmer satisfaction

Most farmers asked (60% of 15) were 'satisfied' or 'very satisfied' with their fences. They invested considerable labour, time and money in their construction and in some cases replicated project fences or increased the size of fenced areas at their own expense.

No problems or accidents were reported with the use of the fences or the movement of livestock in and out. Besides reducing losses to wolves, farmers mentioned several other benefits: i) protection against other predators (e.g. dogs and foxes); ii) improved livestock management and animal handling; iii) a predator deterrent effect of higher human presence; iv) peace of mind knowing that livestock is well protected.

When asked if they experienced any problems or disadvantages in using permanent fences, farmers mentioned higher production costs and increased daily workload. This included additional time needed to confine livestock at night and take them to pasture in the morning when compared to the 'traditional' daily visit that can be done at any time. This was particularly pertinent for farms with two or three fences, which were sometimes far apart. The number of fences needed may also be a constraint, considering the cyclical movements of livestock during the year through different pastures, often distant from one another. In such cases, building several fences would further increase costs and labour. Some farmers considered the fences too small, limiting any possible increase in livestock numbers.

5. Discussion and Conclusions

Within the LIFE MedWolf project we helped farmers to construct permanent, non-electric fences to protect their livestock from wolves. Designed to be solid, durable, easy to build and low maintenance, the fences are intended to provide protection at vulnerable times, especially at night or during sensitive physiological states such as parturition and early suckling, weaned animals and replacement heifers. Our

(Photo: Grupo Lobo)

analyses confirmed their efficacy in reducing losses to predation in the extensive grazing systems which are common in areas recently recolonised by wolves in Portugal. The number of wolf attacks and the number of animals killed, injured or missing declined after completion of fences and was lower than at neighbouring farms without such fences. The occurrence of attacks on sheep left outside a fence at night further illustrates the effectiveness of the measure, which can be optimised through consistent proper use.

Participating farmers recognised the efficacy of the fences when used properly, but also noted the extra cost and effort they entail. Long-term provision of financial incentives by the state may help to alleviate this aspect. Night-time confinement of livestock requires changes to current husbandry practices in the area, which may not always be easy to implement due to socio-cultural, economic or technical constraints. New measures often take time to be accepted and adequately implemented as motivation to use them is influenced by multiple factors including knowledge and awareness, confidence in the measures, their cost effectiveness, trust in experts and the availability of economic incentives. It is therefore important to provide farmers with technical support and encouragement over a prolonged period until new ways of working become embedded and self-sustaining. (*Editor's note:* For a case study on identifying and overcoming barriers to the uptake of innovative solutions, see Sibanda et al., 2021 in *CDPnews* issue 22.)

Choice of tools and techniques should be considered within a wider damage prevention strategy. In many instances, the best outcome is likely to be achieved with a combination of measures (see Espuno et al., 2004). Where it is not possible or desirable to keep livestock permanently confined, LGDs can offer useful protection of grazing animals during the day. On the other hand, not all farmers are able to provide suitable conditions to enable LGDs to be effective guardians. In such cases, fencing may be a more straightforward option.

We cannot discount the possibility that lower levels of damage observed at farms with fences may reflect, at least to some extent, deflection of wolf attacks to neighbouring farms where livestock was less protected. If so, the effectiveness of the fences might decline as their use spreads to more farms. A shift in the relative availability of wild versus domestic prey could also play a role. The efficacy of fences should be re-assessed if contexts change to guide adaptive management and selection of measures to be implemented.

Overall, our results indicate the feasibility of protecting livestock with non-electric fences. We want to emphasise that our findings are specific to the intervention area and the farms involved. Prevention measures should always be adapted to the husbandry of individual farms and farmers' ability to implement them.

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