Perspective

EVALUATION OF PREVENTION MEASURES

CAN ASSESSMENT OF DAMAGE PREVENTION BE STANDARDISED?

Robin Rigg[1], Silvia Ribeiro[2], Mattia Colombo[3], Riccarda Lüthi[4], Daniel Mettler[4], Simone Ricci[5], Luisa Vielmi[6], Margherita Zingaro[7], Valeria Salvatori[5]

[1] *Slovak Wildlife Society, Liptovský Hrádok, Slovakia*
Contact: info@slovakwildlife.org
[2] *Grupo Lobo, Portugal*
[3] *Centro Grandi Carnivori, Italy*
[4] *AGRIDEA, Switzerland*
[5] *Istituto di Ecologia Applicata, Italy*
[6] *DifesAttiva, Italy*
[7] *Independent wildlife biologist, Italy*

1. Introduction

Non-lethal methods of preventing damage are commonly advocated as alternatives to culling predators (e.g. Treves et al., 2016). Although often perceived by users, managers and advocates as beneficial, several recent reviews have concluded that there are surprisingly few examples of their effectiveness being demonstrated scientifically (van Eeden et al., 2018a; Eklund et al., 2017; Miller et al., 2016). This is not to say that preventive measures do not work, but rather that they are not often adequately tested. To help address this deficiency, there is a need to develop more rigorous and consistent approaches to assessment and evaluation (van Eeden et al., 2018b).

In order to share practical experience and ideas, a workshop on the *Evaluation of Damage Prevention Measures* was held at Polo Universitario, Grosseto (Italy) on 8th November 2017 as part of the final conference of the LIFE MedWolf project (LIFE11 NAT/IT/069). The workshop was hosted by the Province of Grosseto in collaboration with the Institute of Applied Ecology in Rome, Grupo Lobo (Portugal), AGRIDEA (Switzerland) and the Slovak Wildlife Society (Slovakia). It was attended by 36 managers, researchers and practitioners including project partners and members of the Carnivore Damage Prevention Working Group[1].

The workshop was divided into two sessions: the first focused on livestock guarding dogs (LGDs) and the second on fencing (electrified and non-electrified). Introductory presentations set the context and outlined methods of assessment used in several case studies. This was followed by discussions on how eval-

[1] An international platform connecting researchers and managers to facilitate discussion and collaboration on damage prevention measures, with a particular emphasis on the evaluation process.

uation could be standardised across different contexts to develop reliable, scientifically-based methodologies. Workshop participants also visited sheep farms participating in the LIFE MedWolf project in order to get farmers' perspectives on assessing the success (and failure) of damage mitigation measures.

2. Examples of LGD evaluation

A set of three components defined 40 years ago (Coppinger and Coppinger, 1980) still form the most common framework for assessing LGD behaviour. Attentive dogs accompany and stay close to their flocks, following their movements. Protective LGDs react adequately to strange situations and interrupt predator attacks. Trustworthiness refers to the absence of disruptive or harmful behaviours towards livestock, with the most appropriate behaviours being submission and social investigation (Lorenz and Coppinger, 1986). Presentations in the first session of the workshop showed several examples of how the effectiveness of LGDs has been assessed in different environments, based on these three components but also using a variety of other criteria and sampling protocols.

Grupo Lobo's LGD Programme, which has been running since 1996, has distributed around 600 dogs to livestock farmers in Portugal. The project follows a three-pronged approach to assessment: level of damage, dog behaviour and owner satisfaction (see Ribeiro and Petrucci-Fonseca, 2005 in *CDPnews* issue 9 and Ribeiro et al., 2017 in issue 15). Livestock losses are compared at the same farm before and after the introduction of LGDs, with neighbouring flocks/herds and control flocks/herds without LGDs. Attentiveness (e.g. proximity and orientation toward the flock) and trustworthiness (social/agonistic interactions with the livestock) are assessed by researchers through direct observation. Several different regimes have been used: instantaneous sampling (every minute during the whole grazing period), continuous observation (e.g. 30 minutes in the middle of grazing or when the dog is with livestock in the stable or when moving to/from the stable) as well as the sampling protocols of Coppinger et al. (1983). Behavioural data are used to investigate the influence of environmental variables (habitat, husbandry) and dog characteristics (breed, sex) on LGD performance. Evaluation of protectiveness is usually based on alertness/activity and reaction to unfamiliar people and animals (e.g. other

(Photos: Robin Rigg and Daniel Mettler)

dogs, wildlife), which are used as proxies for protectiveness against predators. This is because interactions with predators are relatively infrequent events that are unlikely to occur during formal sampling periods. Shepherds' ratings of dogs are therefore also collected and compared with behavioural assessments.

The Protection of Livestock and Conservation of Large Carnivores Project in Slovakia used several different metrics to evaluate LGDs (see Rigg, 2005 in *CDPnews* issue 8). Pup behaviour and interactions with sheep were measured with focal observation protocols (4–6 hours of continuous monitoring every two months plus occasional longer sessions, some using night vision equipment). As the conditions in which they were tested often varied, a researcher also scored dogs on the basis of several outcome ratings, such as the degree to which good practice guidelines for raising LGDs were followed and the extent to which a dog became integrated into the flock (bonded to sheep and regularly accompanied them during grazing). This had to be done by the same researcher in all cases to ensure consistency but had the advantage of facilitating comparison between farms as well as investigating possible connections between the environment in which LGDs were raised and their subsequent performance (Rigg, 2004). Protectiveness was tested by filming LGD responses to simulated predator attacks. Shepherds' descriptions of encounters between LGDs and wildlife were also recorded. In addition, losses reported by shepherds and livestock owners were compared at trial farms versus a control group of other farms in the same regions (Rigg et al., 2011).

The Georgian Carnivore Conservation Project conducted a baseline survey of human-carnivore conflict which relied largely on livestock owners' and shepherds' reports of losses to predators and their perceptions of LGD effectiveness (see Rigg et al., 2017 in *CDPnews* issue 15). Data were gathered using a semi-structured face-to-face interview protocol (Rigg and Sillero-Zubiri, 2010). When possible, reports of damage were corroborated through site inspections, wolf monitoring by telemetry, scat content analysis, etc. During subsequent trials aimed at improving the effectiveness of LGDs, a monitoring plan was developed consisting of puppy aptitude tests, focal observations based on a partial ethogram of dog behaviour and observer outcome scores, adapted from those used in Slovakia (Rigg, 2012).

The LIFE WolfAlps project (LIFE12NAT/IT/000807) gathered data for evaluating LGD vigilance strategies, movement patterns and interactions with herders/livestock in the southwestern Alps using a combination of direct observations and tracking devices. The "vigilance attitude" (attentiveness) of LGDs was evaluated based on the sum of behaviours identified in an ethogram (Abrantes, 1997) and quantified using focal and scan sampling designs to assess interactions and distance between LGDs and herders, if present, and livestock during the daytime. GPS dataloggers were used to determine the average proximity of LGDs to night-time enclosures and differences between dog home ranges at night versus during the day. Moreover, this method was used to test differences between LGDs protecting cattle versus sheep. All evaluated LGDs were within the home ranges of three wolf packs monitored by snow tracking, non-invasive genetic sampling and camera trapping. For each pack, reproduction was confirmed with howling techniques so that researchers could investigate variation in LGD attentiveness with distance from wolf core areas. The presence of shepherds was also recorded to assess their impact on LGD performance.

Although not presented during the workshop, there is an example of LGD evaluation from the LIFE MedWolf project (Zingaro et al., 2017). One of this project's actions was to place LGDs at farms in Grosseto and monitor them to evaluate their behaviour and protectiveness toward livestock. Along with the "classic" approach of direct observations described above, GPS pet collars were tested for assessing the spatial and temporal association between LGDs and sheep in the absence of a shepherd as a measure of attentiveness. Thanks to satellite locations, it was possible to quantify two parameters: average dog-sheep distance and overlap between the movement ranges of sheep and dogs using volume of intersection (Seidel, 1992) and utilization distribution overlap indices (Fieberg and Kochanny, 2005). It was also possible to investigate how several environmental variables and dog characteristics can influence both distance and overlap. To obtain information about interactions among LGDs in the same flock, the aforementioned measurements were repeated with pairs of dogs instead of dog-sheep pairings. In addition, it was proposed that GPS pet collars could be used as a tool to help farmers manage LGDs, limiting accidents and conflicts with neighbours. Using the mobile application of the GPS devices, farmers were able to check the position of their dogs and flock at any time and to make a coarse but real-time assessment of LGD attentiveness.

3. Examples of fencing evaluation

The second session of the workshop began with a presentation from AGRIDEA on trials with two captive wolf packs to investigate their behaviour when approaching different types of electrified fences, whether they crossed them and how (www.protectiondestroupeaux.ch). Wolf behaviour at fences was monitored 24-hours a day with a camera system (see Lüthi et al., 2017 in *CDPnews* issue 13). Using the same approaches, further experiments were conducted in autumn 2017 with a third wolf pack at the Sainte-Croix Animal Park (Rhodes, France).

The goal of this second phase was to enlarge the data base, confirm or relativize previous results and address additional questions. When considering standardised methods to measure and compare fence effectiveness, an interesting outcome of the study was that several differences were observed among the three captive wolf packs in their behaviour and ways of approaching fences. For example, while digging under a 2-wire fence was very frequent in one pack, this behaviour was much less pronounced in the second pack and almost absent in the third. Given the fact that the wolf is a species with a high capacity for individual learning, these differences are not surprising and should be taken into consideration when evaluating wolf behaviour towards fences in the wild or when comparing data from different regions and countries.

Installation of permanent metal-wire fences at selected sheep farms in Grosseto within the LIFE MedWolf project provided an opportunity to measure the efficacy of this type of fencing systematically in 2014–2017. Three complementary approaches were adopted. The first was an epidemiological study design based on comparison of a treatment group versus a control group. The treatment group contained farms that received fences and the control group consisted of other farms randomly selected within a radius of 5 km from treatment farms and with a comparable number of sheep (±50%). Numbers of wolf attacks and livestock killed were compared between the two groups throughout one year in order to cover all different phases of the annual life cycle of the wolf (e.g. breeding, pup-raising) which were expected to influence the rate of predation on livestock. The second approach was an ex ante/ex post design, in which numbers of predation incidents were compared before and after installation of fencing. Farms were monitored for an average of 629 days (range: 327–1,021) before fence installation and 739 days (347–1,041) after. The number of attacks and the number of animals killed during each monitoring period was standardised by dividing them by the cumulative number of days per farm included in the period. Finally, a questionnaire was used to assess farmers' satisfaction with the fencing.

4. Barriers and potential solutions to standardised assessment

Workshop participants identified several possible barriers to developing standardised procedures for evaluating the effectiveness of damage prevention measures. Researchers and practitioners often lack the resources needed (time, funding, appropriate sample sizes, technical expertise and/or methodologies) to carry out rigorous and reliable evaluation. To demonstrate a reduction in damage, losses should be compared not only with those suffered at the same farm prior to intervention (before-after comparison) but most importantly with similar farms not using

the particular preventive measure (treatment versus control). Damage levels are often influenced by other variables, such as weather, habitat, predator populations and husbandry practices. It can therefore be problematic to find control farms which are comparable. There may also be difficulties obtaining reliable data on attacks and losses as these can be hard to verify.

Attentiveness of LGDs is a key behavioural component that can be readily assessed by direct observation in relation to livestock and shepherds, if present (Coppinger et al., 1983). However, direct observation is impaired by darkness, bad weather conditions, complex terrain and thick vegetation, while the presence of observers may influence the behaviour of LGDs. Gathering positional data using GPS collars (e.g. Zingaro et al., 2017) is potentially a better alternative.

Protectiveness and trustworthiness can be assessed by researchers using observation protocols and ethograms but as these behaviours tend to occur less frequently and can be difficult to observe they may not be registered during short sampling periods. Episodic events of untrustworthiness can happen when dogs are not supervised, thus making it difficult to confirm their involvement in incidents of injured or killed livestock. On the other hand, attempts by predators to attack livestock, successfully repelled by LGDs, might go undetected, particularly if they occur during the night or in densely vegetated areas (Landry et al., 2014). Some studies have used experimental tests to simulate approaches of predators (e.g. Kinka and Young, 2018; Rigg, 2004). In Switzerland, adult LGDs are put through a series of behaviour tests to assess their reactions towards an unfamiliar person or dog, while with or without the flock, and to the approach of a remotely controlled wild boar dummy (Pfister and Nienhuis, 2017).

Typically, shepherds spend far more time than researchers with their animals and so can provide valuable insight on LGD performance and behavioural issues via questionnaires or interviews. However, such reports may be subjective and prone to observer bias. In Georgia, for example, shepherds and sheep owners frequently perceived LGDs differently from dog breeders and their ratings of dogs did not correspond to reports of losses to predators (Rigg et al., 2017). In Portugal, while owners' ratings of LGD behaviour were found to correlate with observational data, they were not available for all flocks as some were not shepherded. In addition, some studies have also assessed owner satisfaction, which may relate to other factors besides prevention of losses, such as perceived benefit versus cost and possible conflicts with neighbours due to use of LGDs.

Farms vary and individual LGDs therefore work in different environments. Differing confounding variables both within and between projects/areas are problematic to ensure comparison of like with like. This difficulty cannot be overcome simply by removing LGDs from the conditions in which they normally work and testing them in a standardised environment (e.g. excluding all other dogs), because different dogs will thereby experience different degrees of novelty (e.g. some dogs are used to work alone while others are usually with other LGDs).

Fencing might appear to be simpler to assess than LGDs, but it is not merely a question of checking technical parameters such as electrification, grounding and spacing between wires. To find out if a fence is correctly built and with sufficient electrical power is very often not only a problem of resources but also a lack of reliable standards. Confounders (external variables) may obscure comparison of treatment (fence) versus control (no fence) groups and, as with LGDs, difficulties may arise when gathering and verifying data to determine whether numbers of attacks or losses differ between groups. Experimental study designs and statistical analyses make assumptions, some of which may be violated when assessing the efficacy of preventive measures on working farms. These assumptions include:

- Damage levels are reported accurately;
- Preventive measures are installed correctly and well maintained;
- There is no change over time in the control group;
- There is no difference in data collection between treatment and control groups.

5. Conclusions and recommendations

Before we can assess whether a particular measure is effective, we must first define what we mean by "success". What makes a good livestock guarding dog or predator-exclusion fence? The most important question for farmers and politicians in likely to be: do they reduce damage? Thus, methods and quality of data used for comparing damage levels with versus without prevention measures should be improved as much as possible. As discussed above, these types of comparisons are not always straightforward in the field. Instead, researchers have often assessed proxies such as dog behaviour, assuming that a "good" dog "works". This approach also has difficulties. Moreover, besides technical evaluations, it is important to take the views of end-users (farmers) into account, as ultimately they are the people who should be satisfied. Thus, thorough evaluation probably requires a combination of different methods.

Participants of the workshop in Grosseto agreed that the "traditional" categories used to assess LGD behaviour (attentive, trustworthy and protective) still provide a relevant and useful framework, but other behaviours that may cause management problems are becoming increasingly relevant (e.g. aggression towards unfamiliar people and dogs, chasing vehicles or wildlife). There is a need to standardise the definition and measurement of LGD performance outcomes and to develop specific tests (replicating common, relevant situations) that can be used in different settings. New and developing technologies such as GPS collars, night vision equipment, infrared cameras and cameras mounted on collars or drones can provide additional sources of data to supplement, or in some cases replace, the time-consuming, labour-intensive work needed to collect sufficient behavioural observations.

In practice, money and time are often constraining resources. In order to become standardised, experimental approaches and test protocols must be replicable, efficient and affordable. While lengthy and intensive observations provide detailed information regarding dog ethology and performance, results should be calibrated with simpler, cheaper methods to provide a lowest common denominator that can be compared across studies. It is important to develop methodologies and instruments that can be used in different contexts, allowing valid comparisons between contrasting farms and geographic areas. A relatively simple step in this direction could be the definition of a set of common questions to be used in questionnaires or interviews assessing owner satisfaction and perception of dog performance. The reliability of this approach should be verified through the establishment of correlations between scores of LGD behavioural components, damage analysis and owner satisfaction ratings.

References

Abrantes R (1997) Dog language – an encyclopedia of canine behavior. Wakan Tanka Publishers, Naperville, IL, USA, 263 p.

Coppinger L, Coppinger R (1980) So firm a friendship. Natural History 89, 12–26.

Coppinger R, Lorenz J, Glendinnig J, Pinardi P (1983) Attentiveness of guarding dogs for reducing predation on domestic sheep. Journal of Range Management 36, 275–279.

Eklund A, López-Bao JV, Tourani M, Chapron G, Frank J (2017) Limited evidence on the effectiveness of interventions to reduce livestock predation by large carnivores. Sci. Rep. 7, 2097. doi:10.1038/s41598-017-02323-w

Fieberg, J, Kochanny CO (2005) Quantifying home-range overlap: the importance of the utilization distribution. J. Wildl. Manage. 69(4), 1346–1359. http://dx.doi.org/10.2193/0022-541X(2005)69.

Kinka D, Young JK (2018) A livestock guardian dog by any other name: Similar response to wolves across livestock guardian dog breeds. Rangeland Ecology & Management 71, 509–517. https://doi.org/10.1016/j.rama.2018.03.004

Landry JM, Millischer G, Borelli JL, Lyon G (2014) The CanOvis project: Studying internal and external factors that may influence livestock guarding dogs' efficiency against wolf predation. Preliminary results and discussion. Carniv. Damage Prev. News 10, 21–30.

Lorenz JR, Coppinger L (1986) Raising and training a livestock-guarding dog. Extension Circular 1238/April. Oregon State University Extension Service, 8 p.

Lüthi R, Hilfiker D, Tolon V, Landry J-M (2017) Wolf behaviour towards electric fences used in agriculture. Carniv. Damage Prev. News 13, 11–16.

Miller JRB, Stoner KJ, Cejtin MR, Meyer TK, Middleton AD, Schmitz OJ (2016) Effectiveness of contemporary techniques for reducing livestock depredations by large carnivores. Wildlife Society Bulletin 40(4), 806–815. doi:10.1002/wsb.720

Pfister U, Nienhuis C (2017) Official Swiss livestock guarding dogs. Carniv. Damage Prev. News 16, 34–42.

Ribeiro S, Petrucci-Fonseca F, (2005) The use of livestock guarding dogs in Portugal. Carniv. Damage Prev. News 9, 27–33.

Ribeiro S, Guerra A, Petrucci-Fonseca F (2017) The use of livestock guarding dogs in north-eastern Portugal: The importance of keeping the tradition. Carniv. Damage Prev. News 15, 9–18.

Rigg R (2004) The extent of predation on livestock by large carnivores in Slovakia and mitigating carnivore-human conflict using livestock guarding dogs. MSc thesis, University of Aberdeen, Aberdeen, UK, 263 p.

Rigg R (2005) Livestock depredation and livestock guarding dogs in Slovakia. Carniv. Damage Prev. News 8, 17–27.

Rigg R (2012) Improving the effectiveness of livestock guarding dogs as used by the Tusheti sheep farmers of Eastern Georgia: Monitoring plan for a trial of LGDs. Fauna & Flora International, Cambridge, UK & NACRES, Tbilisi, Georgia, 32 p.

Rigg R, Sillero-Zubiri C (2010) Baseline survey of human-carnivore conflict. Unpublished Report to Georgia Carnivore Conservation Project. Fauna & Flora International, Cambridge, UK & NACRES, Tbilisi, Georgia, 58 p.

Rigg R, Find'o S, Wechselberger M, Gorman M, Sillero-Zubiri C, Macdonald DW (2011) Mitigating carnivore-livestock conflict in Europe: lessons from Slovakia. Oryx 45(2), 272–280.

Rigg R, Goldthorpe G, Popiashvili T, Sillero-Zubiri C (2017) Livestock guarding dogs in Georgia: a tradition in need of saving? Carniv. Damage Prev. News 15, 19–27.

Seidel KS (1992) Statistical properties and applications of a new measure of joint space use for wildlife. Thesis. University of Washington, Seattle, USA.

Treves A, Krofel M, McManus J (2016) Predator control should not be a shot in the dark. Frontiers in Ecology and the Environment. doi/10.1002/fee.1312

van Eeden LM, Crowther MS, Dickman CR, Macdonald DW, Ripple WJ et al. (2018a) Managing conflict between large carnivores and livestock. Conservation Biology 32(1), 26–34. doi:10.1111/cobi.12959

van Eeden LM, Eklund A, Miller JRB, López-Bao JV, Chapron G, et al. (2018b) Carnivore conservation needs evidence-based livestock protection. PLoS Biol 16(9): e2005577. https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.2005577

Zingaro M, Salvatori V, Vielmi L, Boitani L (2017) Are the livestock guarding dogs where they are supposed to be? Appl. Anim. Behav. Sci. 0–1. doi:10.1016/j.applanim.2017.10.002