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LIVESTOCK GUARDING DOGS TODAY: POSSIBLE SOLUTIONS TO PERCEIVED LIMITATIONS

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Special Feature

LIVESTOCK GUARDING DOGS TODAY: POSSIBLE SOLUTIONS TO PERCEIVED LIMITATIONS

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Exchanging experience and finding solutions to problems facing the use of livestock guarding dogs (LGDs) in modern societies were among the goals of a meeting organized in Portugal from 20th to 21st October 2015 within the scope of the LIFE MedWolf Project (www.medwolf.eu). The meeting was attended by 16 specialists from around Europe (Portugal, Spain, France, Switzerland, Italy, Croatia, Slovakia and Bulgaria), as well as from Australia and the USA.

In this article we outline constraints on the use of LGDs identified during the meeting and summarize the main solutions proposed. We have grouped the issues into 10 main topics ranging from a lack of quality dogs to personal, social, cultural, economic, time, management, technical, legal and political constraints. Guidelines on the proper raising and caring of LGDs

are not the focus of this article, since a great deal of information is already available, including on specific solutions to common problems.

1. Personal constraints

1.1. Lack of affinity with LGDs, motivation or willingness to accept responsibility for livestock protection

One major concern about the implementation of LGDs is farmers' resistance to accept responsibility to protect livestock, and their lack of motivation to use LGDs, sometimes based on a low affinity with dogs (Fig. 1). Hired shepherds who do not own the livestock under their care may be particularly reluctant to take on additional tasks required to raise LGDs.

LIVESTOCK GUARDING DOGS TODAY:

POSSIBLE SOLUTIONS TO PERCEIVED LIMITATIONS

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Although the lack of motivation/affinity to dogs can be overcome with education, networking and experience, and may not be a widespread problem (dogs are common on farms, and many people in rural communities keep dogs as pets), resistance to accept responsibility to protect livestock from predators is definitely more challenging. This is frequently grounded in other motives, like the lack of experience or the additional work and costs of using LGDs and potential problems associated with their use (see below), but is mostly due to lack of acceptance of predators' presence. Further studies are needed to identify ways to improve acceptance rates of predator presence.

To increase acceptance, a participatory approach should be developed and a strategy should be drafted together with farmers. Furthermore, it is possible



Fig. 1. Affinity and motivation to use LGDs can be limited in regions where their use was not part of the traditional husbandry, contrary to what happens in Croatia, where shepherds still value the work and company of their Tornjak Dogs (Bosnian and Herzegovinian – Croatian Shepherd Dog) (top), or in Portugal, where in some regions farmers are happy to get an Estrela Mountain Dog pup (bottom).

to work to change this attitude by sharing information and raising the awareness of the community, and of farmers in particular, about the benefits of using LGDs. Economic, ethical, and welfare issues concerning wildlife and livestock can be used to convince farmers to use long-term non-lethal tools to mitigate conflicts.

Farmers' responsibilities regarding the welfare of their livestock and the need to protect them from predation should be made clear. In this case, it is also important to highlight that other measures, such as lethal predator control, despite its immediate results, may in fact be more costly, have a fleeting impact, or lead to increased damages, not guaranteeing the desired long-term damage reduction (Allen and Gonzalez, 1998; Krofel et al., 2011; McManus et al., 2015).

Good examples could be disseminated and advocated by expert farmers and, when necessary, demonstration projects implemented. Promoting engagement with farmers experienced with the use of LGDs, providing financial incentives for implementing LGDs, and providing technical support – not only about the use of LGDs but extending this to other aspects of farm management – may help increase LGD use and acceptance.

Linking monetary compensation to the use of damage prevention measures, namely LGDs, will probably facilitate this process, which should always be monitored by experienced advisors. To obtain the best possible results in LGD management, certain obligations and criteria for farmers should be prescribed.

Farmers who remain reluctant to implement mitigation measures should not be encouraged to use LGDs, since that could have negative effects on the dogs' welfare and efficiency, and consequently be detrimental to the successful implementation of this damage prevention tool. In extreme situations where a dog's welfare or upbringing is compromised, facilitating transfer of the LGD to another farmer might be the best option.

2. Social constraints

2.1. Conflicts with the community

The deployment of LGDs has the potential to create conflict with other interest groups, which may constrain the use of LGDs. This constraint, which could be grounded in the lack of knowledge and experience with LGDs, could lead to inappropriate behaviours, and which could be aided by societies' intolerance and prejudices towards dogs, may surface



Fig. 2. Educational materials produced in France and Bulgaria to inform children and adults on the function and behaviour of LGDs and how to behave in their presence.



in some situations and regions. This is evident in areas with high human presence, particularly in areas with high tourism. Even in less populated areas, conflicts may also occur with neighbours, other farmers, or hunters. Each conflict should be assessed in order to help devise best practices and reach coexistence between all activities, both traditional and more contemporary.

Solutions involve education and communication actions, as well as the selection and training of dogs. Ideally, education and outreach could be conducted in advance of dogs being placed. Communication campaigns directed to the community could provide information about the function and behaviour of LGDs, and on how to behave in their presence. Specific initiatives already exist in some countries. For example, in France a comic was produced by Direction Départementale des Territoires des Alpes de Haute-Provence (DDT 04) to inform children and adults on the function of LGDs and how to behave in their presence, which was later adapted in other countries, like Switzerland (Fig. 2).

In Portugal, Grupo Lobo and dog breed clubs organize talks and visits of LGDs to schools to interact with children and to teach them about how they work (Fig. 3), and in Bulgaria, Semperviva and



Fig. 3. LGDs visit schools to teach children about their important work and how they should relate with these dogs. Such actions are frequently developed in Portugal, either by Grupo Lobo, in collaboration with local farmers and dog breeders, but also by dog breeders.



Fig. 4. Examples of signs used in different countries to warn about the presence of LGDs in the pastures with livestock, and inform on how to behave in their presence to avoid interfering with their work and prevent potential conflicts (left to right: Switzerland, Italy and Australia).

the Balkani Wildlife Society, developed an exhibit and an activities' book for children focusing on large carnivores and the role of LGDs (Fig. 2). Similar initiatives and programmes could be made mandatory in other regions where LGDs are used. Such campaigns could be complemented with warning signs about the presence of LGDs in pastures, and also schematic information on how to behave and handle other dogs where LGDs are present. For example, in the USA, France, and Switzerland, signs are available for farmers using LGDs on either public or private lands to post warnings and provide information. Such signs have been produced and made available to farmers in other European countries under specific projects, and can easily be provided by Farmer Associations (Fig. 4).

A participatory approach should be used to promote dialogue between farmers and the hunting community, focusing on the importance of controlling hunting dogs, and the legal liabilities associated with shooting LGDs, clarifying rights and responsibilities, devising solutions to accommodate all activities, address concerns, and enhance policies. Examples to minimize the risk of encounters between LGDs and hunters can include not using the same areas at the same time, changing grazing areas during the hunting season, or restraining LGDs when hunting is taking place, when feasible. In areas with high predation risk this may not be possible if it will increase exposure of livestock to

predation. Specific education campaigns could be directed to tourists and tourism operators, including posters or leaflets made available in tourist information offices, videos and websites, and explanatory panels at the start of trails. Tourism activities and grazing panels could be coordinated to prevent conflict. Promotional activities could include bringing people to farms or taking LGDs to the community to familiarize people with them (Fig. 5).

Educating farmers to improve LGD control is also important. Promoting networking and experience ex-



Fig. 5. Visits to farms promote socialization between LGDs and tourists decreasing dog aggressiveness towards strangers, and raise people awareness about their important role and on how they work.

change among farmers, as well as providing them with proper technical support on raising and training LGDs to avoid undesirable behaviour, may help to solve or prevent conflicts. Buying insurance for any legal liability can also help.

Selecting and training dogs to reduce aggressiveness and conflicts with other dogs and humans is also important. This means selecting dogs (by breed and behaviour) that are best adapted to local conditions and are more dog/human friendly, but without compromising their efficiency against predators. Other useful steps include adequately socializing LGDs with humans and other dogs, providing extra human socialization for LGDs exhibiting human-aggressiveness/shyness, and controlling and training LGDs to reduce the possibility of them leaving pastures and wandering away from livestock (Figs. 6, 11). This monitoring and training can be aided or even done by advisors, with the support of the government or local associations. Some examples already exist in France (e.g. La Pastorale Pyrénéenne). If necessary, and where possible, LGDs can be on a leash or muzzled while passing through villages, and when livestock are stabled at night LGDs can be enclosed to avoid wandering and other problems. If LGDs continue to exhibit undesirable behaviours they should be transferred to pastures less used by tourists/hunters or removed altogether. In this case, the use of alternative non-lethal methods should be considered.

Spaying or neutering working LGDs can reduce wandering (e.g. Green and Woodruff, 1988, 1990; Lorenz and Coppinger, 1986), and it can facilitate multiple LGDs working together in a group without conflict (van Bommel, 2010). Neutered LGDs were found to be equally effective as sexually intact LGDs



Fig. 6. If done properly LGDs can learn not to cross electric fences, like this Estrela Mountain Dog in Portugal. This can be used to control their movements and prevent them from leaving pastures.



Fig. 7. LGDs work best in a group, but it is important to have a balanced dog team to optimize each dog abilities and joint performance, like in this group of Karakachan Dogs in Bulgaria.



Fig. 8. Kangals are used to protect open-ranging sheep in the USA from large predators like wolves, coyotes and bears. Photo: NWRC.

in protecting livestock from coyotes (*Canis latrans*) in the USA (Green and Woodruff, 1988, 1990; Lorenz and Coppinger, 1986) and carnivores in Africa, including cheetahs (*Acinonyx jubatus*) and leopards (*Panthera pardus*) (Marker et al., 2005a,b). Concerns have been raised that neutered LGDs might not be as effective as sexually intact ones when protecting livestock from wolves (*Canis lupus*), but we are not aware of any scientific data supporting this assertion and it should therefore be further investigated. Neutering makes LGDs less distracted by breeding urges or caring for pups, and therefore more attentive to livestock, but also prevents the farmer from breeding them and producing replacement pups. However a select pair can be kept intact for breeding purposes, under closer supervision by the farmer. In some countries, like Australia and the USA, farmers are actively encouraged to neuter/spay their guardian dogs to prevent behavioural problems, and, in Australia, to prevent the risk of breeding with dingoes (*Canis dingo*). In other countries neutering/spaying is not common. For instance, in Bulgaria traditionally only problem dogs are neutered/spayed. Intact dogs should always be kept under close supervision of the farmer to avoid unwanted breeding.

It should be borne in mind that dogs work in a group, and thus it is important to have a balanced working dog team, i.e., having an appropriate number, sex, and age ratio of LGDs, and individuals with adaptive/complementary behaviours in each context (e.g.

Iliopoulos et al., 2009) (Fig. 7). Some of these solutions are already being implemented with good results (e.g. Gehring et al., 2011; Ribeiro and Petrucci-Fonseca, 2004), but additional research should be developed, mainly regarding dog selection and training.

3. Cultural constraints

3.1. Lack of traditional knowledge

The lack of traditional knowledge in regions where LGDs have never been used or where their use was discontinued following the eradication of large carnivores can be an obstacle to their implementation. However, LGDs have been successfully introduced where there was no known tradition, such as in the USA, Australia, parts of Africa and more recently in the Nordic countries and Germany (e.g. Coppinger et al., 1987; Hansen, 2005; Levin, 2005; Marker et al., 2005a; Otstavel et al., 2009; Reinhardt et al., 2012; van Bommel and Johnson, 2012) (Figs. 8, 9).

Measures to aid the establishment or recovery of LGD use can include working across political and cultural boundaries to share information and raise awareness of their advantages, promoting contacts with farmers experienced with LGDs in similar husbandry conditions, and providing training and technical support to farmers who want to start working with them. Subsidies for using prevention measures is a good option and could be especially helpful to promote LGDs



Fig. 9. The Maremma Sheepdog is used in farms across Australia to protect sheep, goats or cattle from wild dogs, but also less typical livestock, like domestic fowl.

in areas anticipating the return of large carnivores, considering the implementation of LGDs may take some time to reach optimal levels of dissemination and efficiency. Such measures have been implemented in several countries, for example Bulgaria, where in the scope of the agro-environmental measures, farmers using autochthonous LGD breeds to protect livestock grazed in high mountain pastures inside National Parks receive higher subsidy values per hectare.

Along with technical advisory programmes, information could be provided to farmers via printed materials, websites, documentaries, or even in a series of television programs. Information, including detailed manuals, is already accessible online and could be disseminated in other forms to farmers without internet access. Demonstration projects could be implemented to illustrate and propagate the use of LGDs.

4. Economic constraints

4.1. Cost-benefit decisions

The use of LGDs has inherent costs associated with maintaining dogs throughout their lives (e.g. initial purchase, food, veterinary care, insurance), as well as costs associated with time spent in caring for and training them.

Although the amount of time spent taking care of LGDs by experienced farmers is not very large, on farms with limited resources this can be an issue that limits their use. On farms where the total livestock head count is small, but the number of dogs needed is high (e.g. when livestock is divided into small flocks in small, scattered pastures), the relative cost of dogs as well as the management effort needed to handle them is higher, which may compromise the viability of such farms. This cost and effort is readily accepted by farmers in places where LGDs are traditionally used since they value their dogs, even when they may not strictly be needed, but not so much in places where LGDs are being introduced or reintroduced (Linnell and Les-cureux, 2015).

Dog mortality and illness, or inefficiency, are additional constraints that can reduce the success of working dogs (e.g. Lorenz et al., 1986; Rust et al., 2013). Furthermore, in most situations, the use of LGDs may reduce but not eliminate predation, so in areas with very low or extremely high predation risk – where LGD mortality by wolves may be high (Bangs et al., 2005) –, it may not be cost-effective.

It is thus fundamental to increase benefits and reduce costs. This can be done by increasing efficiency

of LGDs through better selection, training, and management, adding more LGDs, or replacing lesser performing LGDs. If several dogs are used together, the age structure should be considered, with more mature and experienced dogs in the group. Technical support should be provided to farmers to reduce costs and increase efficiency in the use of LGDs. Economic incentives from government agencies (e.g. by dedicating resources from rural development or wildlife conservation programmes) or NGOs could also be implemented to compensate for economic costs. If LGDs are not spayed/neutered and breeding is possible, selling LGDs to other farmers or as companion animals to people who are familiar with the breeds' needs may provide an additional source of income.

In all cases, a cost-benefit analysis should be undertaken beforehand. The result will often be favourable in the long-run, since LGDs tend to pay for themselves with the stock saved from predation (e.g. Coppinger et al., 1987; Green et al., 1984; Marker et al., 2005a; van Bommel and Johnson, 2012). Additionally, predator-friendly farming labels have been used to add value to livestock produced by farmers using LGDs which can help offset costs (Marker and Boast, 2015). Even so, it is important to monitor and promote their indirect

and direct benefits (e.g. facilitate herd management, reduce disease transmission from wildlife, and exclude mesopredators or livestock competitors; see Gehring et al., 2010a,b; van Bommel and Johnson, 2016) (Fig. 10).

If the use of LGDs is considered economically unviable, other non-lethal prevention methods should be implemented or used in conjunction with dogs. Implementing LGDs may take some time to achieve efficiency, so farmers should be encouraged to be proactive and be prepared in advance, especially in areas where increases in predator population size is expected.

5. Time constraints

5.1. Effort and time investment in raising and care of LGDs

Some farmers may consider the time invested to raise and maintain LGDs a constraint. Every method requires some time investment and maintenance, and when considering the time involved in other farm activities, taking care of LGDs (e.g. feeding) is not very time-consuming. Nevertheless, in some cases adding extra effort to an already hard working routine can be tough (e.g. typically when shepherds need to bring food to LGDs on a daily basis, especially when



Fig. 10. The Rafeiro of Alentejo is used in farms in the south of Portugal, outside the wolf range, to protect domestic pigs from mesopredators, and keep wild boar (*Sus scrofa*) away from the pastures. These dogs reduce the transmission of diseases to the domestic pigs, prevent wild boar from breeding with and injuring them, and exclude the wild species from the pastures avoiding competition with the domestic one. Photo: Joaquim Pedro Ferreira.

the herd grazes and beds far from the shepherd hut).

Livestock breeders must be familiar with the requirements of raising LGDs before making the decision to use them. Educating farmers to be more efficient in raising and training LGDs or providing them with already experienced adult dogs are solutions to be considered. If LGDs are acquired at a later age, already properly socialized with livestock, the farmer will not need to invest as much time as when raising a puppy, and the dogs can start working almost immediately, after a period of habituation. Good examples exist regarding the transfer of adult dogs to new flocks or herds (e.g. Coppinger et al., 1987; Mettler and Lüthi, 2009; van Bommel, 2010; van Bommel and Johnson, 2012). This could be optimized with a follow-up by experienced advisors, who could also be available to help solve any problems that may arise. However, in some cases, farmers may be less concerned with their LGDs if acquired at a later age compared to LGDs

received as puppies. In the latter case, owners spend more time with the LGDs and experience their puppyhood and juvenile periods, which could result in a stronger bond between them.

When compared with the time invested in other farm tasks and considering the value of the livestock saved by the LGDs, the outcome is likely to be very positive. Thus, investing in dogs should be rewarding in the long run. Nevertheless, subsidies to compensate for the extra effort involved could help overcome concerns from farmers new to LGDs.

5.2. Mismatch of intervention urgency with operational activity of LGDs

LGDs need time to reach adulthood and become efficient guard dogs. It takes around 18–24 months, for LGDs to reach full physical and mental development, and gain the experience needed to deal with predators. Therefore obtaining young LGDs is not appropriate when the need for protection is urgent.

Farmers should be aware of potential predation risks and encouraged to be proactive. They should get LGDs in advance or when damages are still low (Fig. 11). The delay in attaining optimal protection with LGDs can be reduced by using older pups already bonded to livestock or even experienced adults to work with the stock instead of (or in addition to) pups, as discussed previously. However, care should be taken during the bonding process of livestock to new pups or adult dogs to prevent inappropriate behaviour (see section 6.3). Creating a network of LGD breeders can facilitate access to pups and adult dogs as well as sharing of experience.

Other measures can also be implemented to provide temporary protection to livestock before LGDs reach adulthood (e.g. night confinement, shepherding, fladry and turbo fladry, scary sounds or flashing lights). Technical support can be important to provide the best advice to farmers.

6. Dog constraints

6.1. Restricted dog breeds

The classification of LGD breeds as dangerous in some countries (e.g. Spanish Mastiff in certain cantons of Switzerland), although not common, can greatly limit the use of LGDs. If it is not possible to use breeds that are not listed as dangerous, work can be focused on educating policy-makers and lobbying for delisting, or creating exceptions for working LGD breeds. The mandatory use of damage preven-

tion measures, including LGDs, in areas where large carnivores are present can probably facilitate the delisting process and should be considered. If the problem persists, alternative solutions include importing other dog breeds and creating a network of breeders working with non-restricted breeds to facilitate access to them.

6.2. Lack of access to good working LGDs

Difficulties of access to good working LGDs can be a problem, especially in areas where they have never been used traditionally or where their numbers were reduced following the eradication of large carnivores. Furthermore, due to different selection pressures, some breeds/lineages may have lost their working abilities (Sedefchev, 2003). A good solution is the creation of a network of breeders/farmers for the exchange of pups, knowledge, and information about good working dogs. A breeding programme, based on good working dog lineages and controlled mating and breeding, can be initiated to improve LGD quality. Creating nuclei of good working dogs is an efficient way to disseminate pups among farmers.

Suitable breeds and dogs can be imported, and establishing partnerships with LGD programmes abroad may make it easier to access good working dogs from other countries at lower costs. Farmers should have access to information to learn about the breeds or lineages that best suit their husbandry and environmental conditions. Some effort should be made to find good working dogs; the internet and knowledgeable advisors can be sources of information.

Further research should be done on this subject to find the best dog breeds/lines for each region and livestock management practices, and proper selection criteria.

6.3. Mistakes in raising and training LGDs

To achieve an effective adult LGD requires not only selection of a suitable pup but also raising it in a correct manner. Failure to do so can result in a dog with a tendency to wander, or which is insufficiently protective, harms livestock, or is overly aggressive to people. For example, although 86% of LGDs raised during trials in Slovakia showed good or acceptable patterns of behaviour, only 50% of them were successfully integrated into flocks (Rigg, 2004).

Farmers and shepherds should be encouraged and supported to follow guidelines for raising and training LGDs. In some cases, it may be possible to provide them with older and previously trained LGDs, reducing the onus on the farmer whilst facilitating the integration process and lessening the risk of it failing.



Fig. 11. LGDs are only fully effective after reaching adulthood, and thus a proactive strategy should be in place to attain optimal protection when predation risk increases, and pups, like these Estrela Mountain Dog (top) or Castro Laboreiro Dog (down) from Portugal, should be bonded in advance with the livestock. When using pups is not viable due to the urgent need of protection, older dogs, already bonded to the livestock may be obtained. Right photo: Joaquim Pedro Ferreira.



Fig. 12. The use of GPS collars can help with specific training needs or control inappropriate behaviours, make monitoring LGD activities easier, like with this Maremma Sheepdog in Australia (top), and even increase the farmers' interest and care for their LGDs, as observed in Italy (left). GPS and bright collars, like the one used by this LGD in France (right), can also help locate dogs that are missing, identify them as working dogs and reduce the risk of being shot by hunters.

GPS collars for LGDs and livestock can be a helpful tool for less experienced farmers or in case of young or less trustful/attentive dogs, since they enable continuous monitoring of the location of the dogs and of the livestock, and help with dog training, by allowing prompt correction of inappropriate roaming behaviour, significantly saving time and effort. This new tool may even increase the farmers' interest and care for their LGDs (Fig. 12).

6.4. Not all LGDs make the grade

Even when LGD pups are selected from suitable stock and raised appropriately, not all of them will become effective working dogs. Around 14% of dogs assessed in Slovakia were found to lack sufficient behavioural traits (Rigg et al., 2011). If such deficiencies are identified at an early age, the dog can be replaced quickly, saving time and money. Tests have been developed to help select pups and monitor their progress, but further validation is needed (e.g. Rigg, 2012). Behaviour can change during early development stages so it may be easier to identify and select against undesirable behaviour.

More information is needed to help in dog selection, and breeders' and shepherds' contributions should be considered when defining criteria, since specific preferences may vary, whilst taking into consideration that a good working dog team requires dogs with complementary behaviours. For example, if a standardized protocol were to be developed and validated scientifically, dog breeders could test young pups and direct them to different functions (e.g. guard, pet).

7. Farm management constraints

7.1. Unsuitable management systems

Changes of husbandry practices during the absence of predators may create additional difficulties to the implementation of LGDs. Adapting and optimizing grazing systems to the use of LGDs, may not be easily undertaken by farmers. A management system might not have the right environment to allow proper bonding between dog and livestock, but it is usually possible to create a suitable setup. For example, livestock can be temporarily confined during the day or for a period of the day (night or hottest period) with the LGDs. Pups can also be placed with confined animals (e.g. young/replacement animals) or during a particular period of the year when the livestock is confined (Fig. 13). Networking in and between communities could help, as sometimes other

farmers may have a better setup, and can bond the pups to stock, which can then be placed at a later age. Of course during the process of bonding a new dog to livestock and when moving LGDs to a new flock, it is important to manage the dogs correctly and provide the right circumstances for them to bond with their livestock, in order to prevent problems such as roaming or aggressiveness to livestock they are not (yet) familiar with.



Fig. 13. LGDs can establish strong bonds with cattle, but extensive management systems may require some initial adaptations to promote the bonding between them. Dogs can be confined with replacement heifers or during the stabling season, as these Great Pyrenees, in Switzerland and France (above), after which they can accompany the herd to the pastures, like these Spanish Mastiffs, in Spain (below; photo: Juan Carlos Blanco). The use of LGDs in less suited husbandry systems can be overcome with proper technical support and networking between farmers.

Livestock protecting their young can be a threat to young LGDs, so pups should not be raised with particularly aggressive mothers. Especially in the case of sheep/goat flocks, extra care should be taken if placing pups during the lambing season to prevent damages that may occur due to playful behaviour from the dogs. When first releasing young dogs into pastures it is important to make sure they are old enough (both physically and mentally) to accompany livestock and defend themselves or escape from predators. Temporary shelters for pups should be provided near areas frequently used by livestock (hay dispensers, water, night-time bedding sites). Livestock can be encouraged to approach dog shelters using treats (e.g. salt blocks).

Other problems relate to the absence of shepherds in some grazing systems. The lack of supervision, mainly during the juvenile period when playing behaviour arise, may result in LGDs chasing and otherwise disturbing the flock, possibly injuring or even killing some animals. It may also allow dogs to start wandering. Such behaviour must be immediately corrected to avoid becoming reinforced. Thus, during this phase of the dogs' development, farmers need to be more vigilant. Selecting pups from attentive and trustworthy progenitors is a good way to reduce the risks and make them easier to manage. In grazing systems where shepherds are absent, special care is needed to guarantee LGD health and wellbeing: shelter, food, and water should always be available and LGDs' condition should be checked daily. Concern for the welfare of LGDs is increasing and specific guidelines have already been established for them (AWA, 2013).

It is important to educate owners about proper management, training, and bonding of LGDs, so they are in good condition and stay with livestock (Fig. 14).



Fig. 14. When properly raised and maintained LGDs can establish strong bonds with livestock and naturally protect it from predators reducing losses, like these Estrela Mountain Dogs in Portugal (left) and Karakachan Dogs in Bulgaria (right). It is important to give less experienced owners detailed information and technical support about proper management and training of LGDs.

time and effort will be required to get them used to each other, as donkeys and llamas generally do not like dogs. Even in cases where they never accept each other, they can still work near each other in different areas with different groups of livestock.

Feasibility studies should be done beforehand to assess the possibility of using LGDs, and which breed and number of dogs are likely to work best for a particular operation. The assistance of a well-trained advisory team can help to devise solutions applicable to each situation, and financial aid for farmers which can help them implement such solutions could be beneficial.

7.2. Management of dogs in winter

In some regions, during winter, when livestock are confined to barns or kept in areas where predators are absent, management of LGDs could be problematic for several reasons. Farmers may not have enough space to keep them, they may frequently bark, and conflicts with neighbours may increase leading some farmers to give up on LGDs.

Proposed solutions include asking someone else (a friend or other farmer with adequate conditions) to look after LGDs if the owner has no space to keep them. LGDs can be kennelled during this period, as long as kennels meet the animal's welfare needs. Kennelling LGDs may not be possible in every country – for example in Switzerland it is not allowed. If they are kept in a kennel or other small area (e.g. a barn with livestock), maintaining access to livestock would be important, as well as taking them for a run or long walk each day to keep them fit and burn some energy, which will make them quieter. Their diet should be adapted by feeding them with low energy food while they are not working.

Better sound insulation of barns could also be implemented. Furthermore, if trained early, LGDs can learn to stop barking on command. Finally, educating neighbours can help them understand and hopefully be more tolerant of working dogs.

8. Wildlife management constraints

8.1. Conservation of endangered species

In particular regions, using LGDs can conflict with conservation efforts and priorities, by disturbing or killing certain species, or through hybridizing with wild canids (e.g. Lescureux and Linnell, 2014; Potgieter et al., 2016). Disease transmission, which may also be a serious problem to endangered species, is discussed below.

Proper dog containment and management is crucial to keep LGDs out of areas where endangered species management takes precedence. Cooperation between wildlife management authorities and LGD owners is important to devise adequate solutions.

Dogs can also be trained to avoid certain areas or species. Working LGDs could be trained so they are desensitised to the endangered species in their area, and only dogs that have successfully been trained allowed in areas containing the species. The desensitisation could be achieved using the scent of the endangered species (for example rags or bedding from the endangered species, supplied to the LGDs from an early age) combined with (where possible) controlled introductions between the LGDs and ambassador individuals of the endangered species, or a closely related non-endangered species.

LGDs can bond with non-predatory endangered species as easily as they can with livestock. For example, in Warrnambool, Australia, Maremma Sheepdogs are successfully used to protect a colony of little penguins (*Eudyptula minor*) from predation by foxes (*Vulpes vulpes*). The dogs live on the island with the penguins mainly during the moulting and breeding season, and keep foxes away (van Bommel, 2010).

If hybridization with wild canids is a concern, such as with wolves or dingoes (Claridge et al., 2014; Kopaliani et al., 2014), LGDs can be spayed or neutered. As explained previously, existing scientific data show that neutered dogs work equally well as intact ones (but see section 2.1). When no solution is viable in making dogs compatible with policies for endangered species, alternative prevention measures should be used.

8.2. Spread of disease risks

Apart from human-caused mortality, LGDs are subject to many diseases that may cause their premature death, permanently incapacitate them, or negatively influence their physical condition and decrease their working capacity. Furthermore, if not properly vaccinated or dewormed, dogs can spread diseases to other dogs, endangered wildlife, livestock, and humans (e.g. Deplazes et al., 2011; Hughes and MacDonald, 2013). On the other hand, LGDs have the potential to deter disease transmission from wild ungulates to livestock, by chasing them away from pastures (Gehring et al., 2010b).

Prevention is key, and with proper and regular veterinary care most problems are easily solved. Owners should have access to experienced veterinarians, specialized in dog care, to regularly monitor and



Fig. 15. The use of illegal methods to lethally control predators can have a big impact on the population of LGDs. Poisoning can be responsible for over 30% of the deaths in some countries, like Portugal, where this Estrela Mountain Dog died after eating a bait poisoned with strychnine.

treat their LGD health, while a hotline for veterinary emergencies should also be available. Education campaigns (leaflets, workshops) could be implemented to raise awareness of basic dog health care and disease prevention. Compulsory vaccinations should be implemented when applicable. Although basic veterinary care is accessible to most farmers, in some cases this can be an issue, therefore financial aid could be a beneficial, especially when LGDs require more expensive treatments. Buying dog health insurance is also a possibility.

8.3. Risks of lethal predator control

Dog mortality is one of the major limits to the use of LGDs and thus any risk should be avoided. Some methods used for predator control, such as the use of poison or traps, constitute a major problem for LGDs and can be a significant cause of mortality. These methods are still used for legal predator control in some countries including the USA and Australia, and are also illegally used worldwide (Glen et al., 2007; Guittart et al., 2010). For example, poisoning can exceed 30% of the known mortality of LGDs in Portugal and Bulgaria (Silvia Ribeiro and Elena Tsingarska, unpubl. data) (Fig. 15).

Risks arising from legal predator control can be more easily solved than in the case of illegal control actions. This can be done by coordinating the timing of interventions, limiting the use of baiting or traps near areas where LGDs are working, moving LGDs and livestock to distant grazing areas during periods of predator control, training LGDs to avoid poisons or traps, or integrating additional dog management methods during hunting seasons (e.g. temporary lockdown of LGDs, enclosed overnight, shepherd presence). Regular communication with authorities and neighbours should be maintained in order to better coordinate activities and avoid risks for LGDs. Responsible entities are typically required to make public announcements and identify areas with traps/poison or hunting days and these actions are strongly encouraged in areas where LGDs are also used.

Communication and information actions could also be developed to address limits on the use of LGDs in areas where legal methods of control are also used. These include educating farmers to enhance vigilance and reduce risks faced by LGDs, training farmers on how to act if a LGD is trapped or poisoned, distributing anti-poison kits if applicable, educating hunters on how to behave in the presence of LGDs and to be

careful not to mistake them for stray dogs, informing hunters and the general public about the consequences and legal liabilities of killing LGDs, putting up signs in areas where LGDs are used to warn hunters and others of their presence, or even having television and radio announcements to inform the public.

Illegal predator control is much more difficult to detect and tackle, and although considered more common in regions where predators are fully protected, it is also frequent in some areas where legal control is used (Chapron and Treves, 2016).

It may be useful to increase anti-poaching control actions, make sanctions more severe, and raise social awareness of the problem. Dogs can be equipped with GPS collars or bells to help locate them in case they fall into traps. The use of e-collars with wireless fence systems may help keep them away from sites where traps/poison are being used. Conditioning dogs to avoid poisoned baits/traps and train them not to pull when caught in snares/traps should also be investigated. This training is already being done in some regions with good results, for example dogs in the USA are trained not to pull M-44 (a spring-loaded mechanism that delivers sodium cyanide to canids that pull it) using capsules filled with hot pepper instead of sodium cyanide (Young, personal communication).

Finally, emphasizing the advantages of non-lethal practices through scientific reasoning may also promote their use and help reduce the risks to LGDs. Recent studies confirm that culling predators may not always be a solution, and in some instances may even increase damage (Allen and Gonzalez, 1998; Krofel et al., 2011; McManus et al., 2015).

9. Advisory constraints

9.1. Advisors lacking adequate knowledge

Although owners/managers can acquire information from a variety of sources and do not always have to rely on consultants, knowledgeable and experienced advisors are important to guarantee the success of this method, especially in the case of farmers not familiar with or less motivated to use LGDs. Sometimes there may be a mismatch between what dog breeders or researchers consider to be desirable traits and what farmers and shepherds value in a working LGD (Rigg et al., 2017: this issue).

Specific training programmes, including technical issues (focusing on problems related to the use of LGDs, their behaviour, education/training and

maintenance) and social skills, and experience transfers can be promoted. Several successful programmes exist and plenty of information is available. Furthermore, control systems can be put in place to guarantee all advisors are sufficiently knowledgeable and skilled.

10. Legal and policy constraints

10.1. Agro-environmental policies and legal context

Incompatibilities may exist between agricultural and environmental policies regarding wildlife conservation. For example, as mentioned above, dogs can disturb or occasionally kill wildlife, thus interfering with local environmental policies. Furthermore, inadequate or negative legal context exists in some countries regarding the presence of LGDs. In some countries LGDs may be considered stray dogs from a legal point of view, while in others the obligation for dogs to be on a leash or confined may hinder their legal status because it is not feasible for working LGDs. These issues may put payment of compensation and insurance at risk.

While trying to implement adequate dog containment and control to avoid the problems previously discussed (e.g. proper training in combination with adequate nutrition can eliminate harassment, chasing, and killing of wildlife), work should be done to adapt legislation, and harmonize different legal instruments. The legal status of LGDs could be clarified and improved or exceptions made for working LGDs, while land management plans should be adapted to their presence.

Setting up an interest group to lobby for change legislation to make it more favourable to the use of LGDs might be a solution. Authorities should be informed about why LGDs are useful, and how they can be incorporated into broader management actions. Communication actions should also be directed at farmers so they are aware of local regulations and of possible solutions to reduce risks and avoid legal problems.

At a pan-European level, a standardised legal frame could be produced concerning the use of LGDs. This could benefit from the production of a pan-European document compiling national legislation, to identify best practices and provide recommendations for new or additional EU policies regarding LGDs in the frame of biodiversity conservation policies.

10.2. Legal liability

LGDs, like many other working or even pet dogs, are subject to risk and may be involved in situations that result in legal liabilities for the owner. The most common problems regard: i) collisions with cars, which can cause major damage to vehicles and injury to the occupants (and may result in the death or serious injury of the dog); ii) chasing and biting people, especially hikers, cyclists and horse riders, which can result in traumatic incidents and serious injury; iii) attacks on other dogs (e.g. hunting, herding or pet dogs, or other LGDs), which can cause injury or death of the other dogs involved; iv) damage to property (e.g. injuring neighbour's livestock, damaging agricultural fields, tearing clothes/equipment) (Fig. 16).

Possible solutions include educating farmers to adequately raise and manage LGDs, increasing LGD supervision and control to reduce risks, and selecting and training LGDs to reduce aggressiveness towards people and dogs. Nevertheless, this should be done carefully so as not to hinder the protection ability of the LGDs. As mentioned above, informing people about the presence of LGDs and how to behave is essential, and the use of warning signs should be encouraged around pastures, tourist trails, or along roads. Road signs to reduce speed complemented with speed bumps and the use of reflective collars or vests on dogs can help prevent accidents, especially at night. Correctly identifying the dog, with microchip and collar tags (containing the name and contacts of the owner), may also help to clarify any situation. Finally, if it is available, obtaining adequate insurance should be encouraged.

11. Conclusions

Most of the limitations to the use of LGDs identified were common throughout the countries and regions represented, but some were specific and require particular solutions. In most cases, viable solutions already exist although they may need to be adapted or improved. Some involve traditional and modern knowledge but others require additional research. Future studies should consider multidisciplinary approaches to address ethological, ecological, anthropological, social, economic and ethical issues.

The discussion surrounding the issues addressed above highlights the need to gather more information about the efficiency of LGDs and their use in different ecological, social and cultural contexts. Empirical



Fig. 16. LGDs chasing or biting hikers can result in legal liabilities for farmers, and adequate supervision of the dogs is essential if pastures are close to hiking trails, complemented with proper information of the public and, if available, with a specific insurance.

knowledge can be very helpful for decision-makers and for farmers considering using LGDs. One example is mortality and risk assessment studies, since early mortality and morbidity can compromise the overall cost-effectiveness of LGDs. Despite the widespread use of LGDs, only a few studies have reported such data, which is fundamental for assessing their efficiency, defining dog care procedures to minimize risks and designing adequate financial aids.

Applying new tools and technologies to monitor and evaluate LGDs is also needed to gather more definitive data and improve their success. Another aspect to consider is the importance of gathering data that could be comparable among studies and regions. Quality research is essential, and we stress the importance of knowing where, when, and why LGDs did not work to deepen our understanding and optimize their use. Education of farmers, decision-makers and the public about the use of LGDs is fundamental, and should draw on new techniques and information to prevent inappropriate use and unnecessary waste of time and money. Efforts should also be made to ensure an adequate legal framework, considering that the legal status of LGDs is highly variable and often blurry, since they are generally free-ranging, and often under little supervision.

This article is a brief contribution to the topic which could certainly gain from additional inputs of specialists from different regions. We hope it will start a wider discussion on how to improve and expand the use of livestock guarding dogs.

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