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Research Article

# Livestock protection methods applicable for Germany – a Country newly recolonized by wolves

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## Abstract

Against the background of the return of wolves into Germany the Federal Agency for Nature Conservation (BfN) commissioned a synopsis and evaluation of large carnivore (LC) damage prevention methods that may work in Germany. The goal was to come up with recommendations for livestock protection measures, prevention- and compensation payment schemes based on experiences in Germany and other European countries. We summarized the German experience, reviewed the existing literature with a special focus on Europe, and send questionnaires to experts in European countries that face similar challenges like Germany. The results confirmed that there is no single livestock protection method providing 100% safety.

However, a couple of methods can reduce damages considerably and have already proved to be successful also under German conditions. Electric fences, when used correctly, are an effective measure for reducing predation on sheep or goats. In most cases electric sheep nets are sufficient as wolves rarely jump over fences. Most effective appears to be a combination of electric fences and livestock guarding dogs (LGD). However, it will be imperative to provide shepherds not only with dogs but also with expert advice on the raising and training of these dogs. When compensation is not coupled with prevention the incentive to use prevention measures accurately may be weak and thus we highly recommend interlinking compensation payment with damage prevention. However, given the current low level of wolf predation on large stock, we presently recommend for Germany to request and consequently financially support only prevention measures for small livestock on a preemptive basis in the area of permanent wolf presence.

## Introduction

Wolves (*Canis lupus*), lynx (*Lynx lynx*) and bears (*Ursus arctos*) were eradicated in most of Central and Western Europe by the beginning or middle of the $20^{th}$ century (Breitenmoser and Breitenmoser-Würsten, 1990; Delibes, 1990; Zedroser et al., 2001). However, societal and economic changes resulted in a revision of the legal status of large carnivores in the 1970ies and 80ies, providing them with a protected status, particular in countries with dwindling or extinct LC populations. Especially wolves benefited from this protection and with their recovery also started to spread into areas where they were eradicated a long time ago (Wabakken et al., 2001; Cubaynes et al., 2009; Sand et al., 2010). Their return was accompanied by conflicts with hunters and farmers who had adapted to

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a life without these top predators.

In areas in Europe where large carnivores have not been completely eradicated livestock owners have always relied on preventive methods. Accordingly damage prevention methods are still best practice in these areas. Where wolves, lynx or bears survived, flocks are usually attended by shepherds and protected with livestock guarding dogs (e.g., Mertens et al. 2002). Often the flock will be confined during the night in a corral (e.g., Mertens et al. 2002; Nowak and Myslajek 2007). In contrast in areas where large carnivores were eradicated, preventive methods were quickly abandoned. Today flocks are often left unattended, especially in mountainous areas. Although this form of husbandry is only a few decades old, the practice of leaving flocks free ranging is now regarded as traditional. With the return of large carnivores, especially wolves, into their former distribution areas conflicts are inevitable (Linnell et al., 1996; Kaczensky, 1996). In Germany the true comeback of wolves began in 2000 when the first reproduction was recorded after more than 150 years of absence. By 2010 the German wolf population had already grown to seven reproducing packs plus five scent-marking pairs (I. Reinhardt and G. Kluth, unpublished data). In combination with the recovery of the wolf populations in Poland (Jedrzejewski et al., 2008) and in the Alps (Marucco and McIntire, 2010) a rapid spread of wolves throughout Germany can be expected. With the return of the wolves, predation on livestock also returned and farmers expressed their concerns that livestock husbandry and large predators are incompatible. Against this background the Federal Agency for Nature Conservation (BfN) commissioned a synopsis and evaluation of large carnivore damage prevention methods that may work in Germany. The goal was to come up with recommendations for livestock protection, prevention and compensation payment schemes based on experiences in Germany and other European countries. Although the original report (Reinhardt et al., 2010) aimed at illustrating preventive methods against attacks from wolves, lynx and bears, this paper focuses on wolves only. We concentrated on protection measures for small livestock like sheep and goats, since they are most frequently killed by wolves in Europe (Kaczensky, 1996, 1999).

### The German situation

Germany is a federalistic country consisting of 16 provinces (in German called Laender; singular Land). Nature conservation is under the jurisdiction of the Laender. Accordingly monitoring of large carnivores as well as prevention and compensation payment schemes differ from Land to Land. In 2010, seven reproducing packs plus five scent-marking pairs were confirmed (I. Reinhardt and G. Kluth, unpublished data). Five packs are located in Saxony, the first of the German Laender that had to deal with reproducing wolf packs and a small but growing wolf population. In total, wolves by now have shown up in eight Laender (Reinhardt and Kluth, unpublished data).

The majority of professional sheep farmer in Germany keep their flocks on pastures fenced with mobile electric fences. Commonly electric sheep nets are used, sometimes also fences with 3-7 electric wires. In general sheep pastures are rather small (< 10 ha) and are moved every few days depending on pasture condition.

Permanently fenced sheep pastures are rare. In some areas nomadic shepherds ("Wanderschäfer", shepherds roaming on pubic lands or negotiating with landowners for temporary grazing rights) still occur. They attend their flocks during daytime and fence them in during the night, mostly using electric sheep nets. Only about 3000 out of more than 2 million sheep graze unattended on alpine meadows in a small part of the German Alps (Tautenhahn, 2008). These sheep are mainly held in small flocks of less than 50 sheep, making shepherding economically ineffective. Apart from this special situation in the German Alps, the precondition for mitigating the wolf livestock conflict seems rather favorable in Germany.

## Methods

In preparation of the report for BfN we reviewed the existing literature with a focus on Europe, including the LIFE - COEX (2008) reports, for experiences with different preventive methods. We started with the Carnivore damage prevention news, published at the LCIE website (LCIE, 2012) and continued with literature referred in the CDP news.

In addition a questionnaire survey was sent to large carnivore and livestock protection experts in selected European countries. We chose countries that were comparable to Germany concerning both the return of large carnivores and the livestock husbandry practice. Consequently we concentrated mainly on countries and regions where large carnivores returned recently and on countries adjacent to Germany. We asked about: (1) the prevention methods used and the prevention and compensation payment schemes implemented and (2) which prevention methods are recommended for sheep/goats and for cattle/horses. To receive further information regarding prevention methods that may be applicable for Germany we asked for details regarding the use of livestock guarding dogs (LGDs) (how many dogs per flock recommended or regulated), a qualitative assessment of electric sheep nets, an assessment on how often wolves dig under or jump over fences. (3) We asked about recommended improvements of prevention methods (questionnaire attached as supplemental material).

Regarding the wolf we received answers from Poland (S. Nowak, Association for Nature Wolf), Sweden (J. Karlsson, Swedish wildlife damage centre / Grimsö wildlife research station), Switzerland (D. Mettler, the Swiss Association for the Development of Agriculture and Rural Areas, AGRIDEA), France (E. Marboutin, National Game and Wildlife Agency, ONCF), Italy (Trentino and Region Piemonte, F. Marucco, Centre for large carnivore management and conservation), Slovenia (P. Ulamec M. Blazic, Ministry for Environment and Spatial Plan-

ning, Environmental Agency of the Republic of Slovenia) and Spain (J.C. Blanco, Conservation Biology Consultants).

## Results

### (1) Prevention and compensation payment schemes

In many European countries compensation is paid for damages caused by large carnivores (Klemm, 1996; Fourli, 1999; Salvatori and Linnell, 2005). However, not always is compensation payment linked to the use of preventive methods. In our survey only Sweden, Slovenia, Poland and some Spanish provinces had compensation of livestock killed by wolves bond to prevention. Switzerland, France and the Italian province Piedmont consider doing so in the future. In Germany two of the Laender with wolf presence (Saxony and Brandenburg) linked compensation to prevention. While in Germany several Leander discuss lower and or upper limits for compensation payments if a damage goes below or exceeds a financial limit, none of the surveyed countries/regions has such thresholds.

In most countries compensation is paid if the culprit species cannot be excluded. That means in doubtful cases, when it is not clear if a wolf or a dog caused the damage, the losses are compensated. Only Slovenia and Switzerland demand clear evidence that the damage was indeed caused by a wolf (e.g. genetic analysis). In general 100% of the market price is paid, in Sweden even 200%.

Funding of prevention measures is not as common as paying compensation. Where wolves have always been present damage prevention measures are regarded best practice. If funded, financial or logistic support for upgrading or intensifying prevention measures will often come within the framework of projects such as LIFE - COEX (LIFE - COEX 2008 Final Report). In contrary, were wolves have made a recent comeback, newly establishing preventive measures is often financed in full or subsidized by government funds (e.g. France). What measures and to what amount prevention measures are financially supported and who is eligible to apply for support differs from country to country and in federal countries from region to region.

As of 2010, three Laender in Germany had provided the legal framework ensuring financial support for preventive measures and several more Laender plan to do so in the future. Presently, Saxony is subsidizing e-fences and LGDs with up to 60%, Brandenburg up to 75% and Saxony-Anhalt up to 80% of the initial cost. However, so far in Saxony-Anhalt only hobby sheep owners, in Brandenburg only professional sheep owners, and in Saxony professional as well as hobby sheep owners are supported. In Saxony prevention and compensation payment schemes are defined in the Management plan for the wolf in Saxony (Sächsisches Staatsministerium für Umwelt und Landwirtschaft, 2009). Compensation after wolf attacks is only paid if sheep or goats were protected according to a clearly defined minimum prevention standard. This regulation came into effect in 2008 after a transition period of one year during which owners of small livestock were informed about the preventive methods conform to the minimum prevention standard, funding opportunities and the fact that compensation will be coupled to prevention. Since then damages have dropped noticeable (Figure 1).

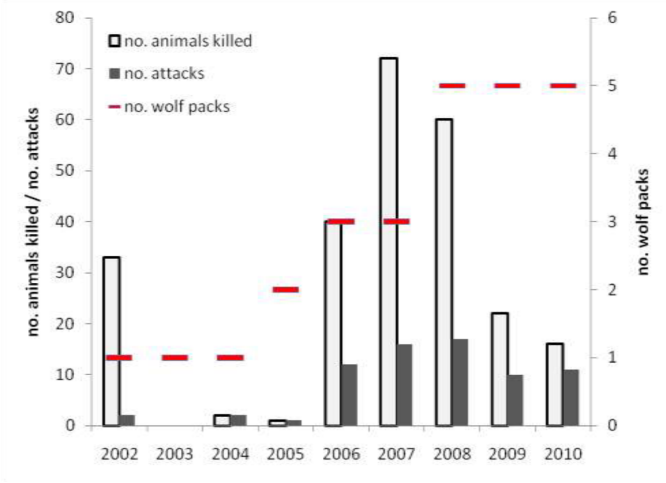


**Figure 1** – Development of wolf pack numbers and wolf attacks on small livestock in Saxony / Germany.

In 2009 and 2010 wolf targeted sheep that were not at all or not sufficiently protected in 71% (15/21) of all attacks. In none of these cases compensation was paid. In 2007 an average of 4.5 sheep were killed per attack. In 2010 this number had dropped to 1.45 sheep killed per attack. This decline is due to the fact that large flocks were rarely attacked since 2008 as a result of their good protection. Most of the insufficiently protected sheep belong to hobby owners. They often keep single sheep or very small flocks.

### (2) Recommended prevention methods

Based on the literature research and the answers to the questionnaires it became quite clear that only a restricted number of methods seems to work or have actually been tested on a large scale to prevent or reduce wolf predation on sheep. Thus in the following we concentrate on these methods which are: non-electric fences, electric fences, LGDs, shepherding as well as a combination of these methods.

In France, Switzerland and Sweden no special preventive methods are suggested for large livestock. In Spain, Poland, the Italian region Piedmont similar preventive methods are recommended for small and large livestock.

#### Non-electric fences

The use of non electric fences for protecting small livestock is not very common in the countries included in our survey. In some countries non electric fences are used

**Table 1** – Answers given in the questionnaire survey regarding the usefulness of electric sheep nets to prevent wolf attacks on small livestock in different European regions and experiences made in different provinces of Italy in the frame of the LIFE - COEX (LIFE 04NAT/IT/000144 - COEX - Report Action D1).

| Country/Region | Use of electric sheep nets | Evaluation | Specification |
|---|---|---|---|
| France | yes | useful | 110 cm, stiff vertical plastic mesh |
| Germany | yes | useful | – |
| Italy/Piedmont | yes | very useful | – |
| Italy/several other provinces | yes | very useful | 100–108 cm |
| Poland | no | – | – |
| Sweden | yes | very useful | 110 cm, stiff vertical plastic mesh; only as acute measure after an attack |
| Switzerland | yes | useful | 110 cm recommended (90 cm also in use) |
| Slovenia | no comment | no comment | 106 cm recommended |
| Spain | no | – | – |

as night corrals (Poland). In other countries their use is not recommended (Switzerland, Italy/Piemonte, Slovenia) or only in combination with livestock guarding dogs (France). In Spain a massive mesh wire fence 200 cm in height with barbed wire on top was tested in the frame of LIFE - COEX. This fence is dug an additional 50 cm into the ground and has proved to be 100% safe against wolves or stray dogs (LIFE - COEX C6, 2008). In Saxony non electric fences are recommended to be at least 120 cm, preferably 140 cm, in height with a protection against digging (defined minimum prevention standard, see above). In Germany this kind of fence is in general only used on small pastures in where people graze just a few sheep as hobby and on a permanent basis.

**Figure 2** – Fladry as an acute measure after a wolf attack. The fladry was drawn around an electric sheep net that was jumped over before (Photo: I. Reinhardt).

While mesh wire fence is not the method of choice for small livestock, it is the commonly used method for deer farms raising red-or fallow deer (*Cervus elaphus* and *Dama dama*) in many European countries. These fences are high enough, usually at least 180 cm, and prevent wolves from jumping or climbing over. However, they need a protection against digging like non electric sheep fences do. Otherwise wolves may easily learn to dig under, which has happened several times in Germany. In these cases a 100 cm wide strip of mesh wire fixed to the ground and to the fence has proven to be an effective protection against digging. Alternatively an electric wire 20 cm above ground and 15 cm in front of the fence is also sufficient (Levin 2000; Wam et al. 2004; Reinhardt and Kluth, personal observation).

A special case of a non electric fence is a fladry, a single line hung 50–70 cm above the ground from which 50 × 10 cm colored strips of fabric hang down at about 50 cm intervals (Figure 2). These fences were originally used for hunting wolves (Okarma, 1993). Today fladry is used in Poland around wooden night corals against wolf attacks (Nowak and Myslajek, 2007). In Germany fladry is used as an acute measure after a wolf attack when no other effective preventive method is at hand. In one case where a flock was attacked three times in three weeks, no further attack occurred after fladry was used. Musiani et al. (2003) showed that wolves could be effectively excluded for 60 days from 25–400 ha cattle pastures where they have been killing cattle before. In two trials the fladry was removed after 60 days, in the third trial wolves crossed the fladry after 61 days. Our own experience also showed that fladry is not a permanent solution, but should be restricted to 2–3 weeks in order to prevent habituation of wolves to this method (Reinhardt and Kluth, unpublished data).

## Electric fences

Electric fences (e-fences), when used correctly, seem to be an effective measure for reducing predation on sheep. In Scandinavia e-fences with five wires or cords at 20, 40, 60, 90 and 120 cm above the ground have proven to be nearly wolf and bear proof (Levin, 2000; Wam et al., 2004). Corresponding recommendations from all areas are to keep at least 4000–5000 V on the fence (Angst, 2002; Mertens et al., 2002; Levin, 2000, 2002; Vidrih, 2002). If voltage is too low some animals may get habituated to light electric shocks (Vidrih, 2002). In Scandinavia mesh wire sheep fences are made predator proof with a ground wire and an additional electric wire 10–15 cm above the fence to prevent climbing of lynx or bears (Levin, 2000; Wam et al., 2004).

In Germany electric sheep nets are the most popular

**Table 2** – Responses to our survey regarding the question "How often do wolves jump over fences?".

| Country | Do wolves jump over fences? | Special preventive recommendations? |
|---|---|---|
| France | sometines | no |
| Germany (Saxony) | sometines | no |
| Italy (Piedmont) | rarely | no |
| Poland | rarely | no |
| Sweden | rarely | no - removal of jumping wolves |
| Switzerland | rarely | no - use of LGDs |
| Slovenia | not specified | – |
| Spain | rarely | no |

method for fencing in sheep and goats. Although these fences are easy and fast to set up, they are only appropriate for small-sized meadows since net fences cannot maintain high voltage over long distances like wire fences. The survey results and our own experience coincide with the results of the LIFE - COEX project: electric sheep nets are regarded as useful or even very useful to prevent wolf attacks (Table 1). Some countries recommend sheep nets of at least 110 cm in height. These should have stiff vertical plastic rods to make the nets more visible and to avoid wildlife running into them, getting tangled or damaging the nets.

### How often do wolves jump over fences?

Our overall experience is that wolves try to crawl or dig under a fence but only very few individuals learn to jump over a fence (Reinhardt and Kluth, unpublished data). From 2002 to 2010 wolves jumped or most likely jumped the fence in 12 out of 71 (17%) wolf attacks in Saxony. Six of these cases occurred in the territory of one wolf pack. After the attacks ceased in this territory they continued in the area of a newly established pack the next year (four cases). Our assumption is that a young wolf of the first pack that had learned to jump over fences founded the new pack, but so far genetic results are still pending. If it was indeed a single individual, this wolf would have been responsible for 83% of the attacks where a fence was jumped. No further fence jumping occurred after a fladry or an additional white cord was attached 20-30 cm above the net fence of the affected pastures (Figure 2, 3). This finding is in accordance with the experience made in other regions (Table 2). Most wolves do not jump over fences. Moreover, no country in the survey had specific recommendations for these cases, except for Sweden where the removal of jumping wolves is attempted.

### Livestock guarding dogs (LGDs)

The use of big dogs for protecting livestock against predators is probably more than 6000 years old (Rigg, 2001). In Europe a great diversity of LGD breeds evolved. However, with the decrease of large carnivores these dogs fell into disuse and in many regions the tradition and knowledge of working with LGDs was more or less lost (Linnell et al., 1996). With the comeback of large carnivores a renaissance of LGDs in Europe began. During the last 20 years projects involving LGDs as a preventive method were initiated in many countries, fostering breeding and spreading of these dogs (e.g. Poland: Nowak and Myslajek 2005; Smietana 2005; Portugal: Ribeiro and Petrucci-Fonseca 2004, 2005; Slovakia: Rigg 2005; Sweden: Levin 2005).

Several projects clearly confirmed the effectiveness of LGDs. The LIFE - COEX project provided 245 LGDs mainly to shepherds in Portugal (92), Spain (75) and Italy (78). In Portugal the damages decreased in 72% of these farms and the overall reduction in damages averaged 27% (13–100%), with an average of 11.08 animals killed per flock per year before and 6.36 animals killed after adult LGDs were integrated. In Spain the number of attacks on flocks decreased by 61% per year after the dogs were introduced (2.4 attacks / holding / year before dogs, 0.9 attacks / holding / year after dogs), and the total number of animals killed decreased by 65% (15.1 / year / holding before dogs, 5.3 / year / holding after dogs) (LIFE - COEX 2008 - Report Action D2).

**Figure 3** – White cord stretched 20–30cm over the electric net fence to keep wolves from jumping over. (Photo: I. Reinhardt).

Espuno et al. (2004) showed that LGDs are most effective if the flock is fenced during the night. LGDs reduced the damages in Mercantour, France on 81% of the fenced pastures, but only on 39% of the unfenced pastures. All

responses to our survey confirmed that livestock guarding dogs are regarded as an effective preventive method, especially in combination with electric fences. The decisive factor for the effectiveness of LGDs, in addition to the confinement of the flock, is the number of LGDs (Espuno et al., 2004) . Some countries recommend a minimum number of dogs: Switzerland, France and Germany (Saxony) recommend two dogs per flock, Poland one dog per 80 sheep and the Piedmont region of Italy and Sweden one dog per 100 sheep. Furthermore, performance of LGDs depends on their correct upbringing and training. In Slovakia the number of wolf attacks as well as the number of sheep killed per attack decreased significantly on farms with LGDs that were raised and trained correctly, but not on farms with dogs that were not well socialized (Rigg, 2005).

#### Shepherding

Where flocks are left free grazing shepherding is a prerequisite for confining the sheep in fenced corrals for the night or keeping them together during the day to enabling guarding dogs to function (Linnell et al., 1996). In some areas such as Scandinavia shepherding is uncommon and therefore not recommended. In the German Alps where flocks are usually small, several herds would have to be integrated into a larger herd to make shepherding cost effective. Alternatively, where feasible alpine pastures could be fenced and sheep left with livestock guarding dogs only.

### (3) Improvement of prevention methods

In the questionnaire survey we asked what the main points of criticism expressed by livestock owners with regard to preventive methods were. The unisonous answer was the additional work load involved with implementing and maintaining preventive methods. To make preventive methods more effective large carnivore and livestock protection experts suggested not only to fund prevention but to offer assistance and training in correctly applying the preventive methods. However, one respondent also stated that the acceptance of preventive methods grows with growing suffering.

## Discussion

In most member states of the EU compensation systems for damages caused by large carnivores are implemented. Often these regulations are especially developed for large carnivores, acknowledging that large carnivore conservation is in the interest of society as a whole. Consequently the solidarity principle demands that the associated costs should be carried by all, rather than be burdened onto a few directly affected farmers (Klemm, 1996; Fourli, 1999).

The differentiation between sheep killed by wolves and those killed by dogs can be extremely difficult (Boitani, 2000). Moreover, the differentiation between wolf and dog damages is not only a technical problem, but also a human dimension issue, since most livestock owners believe that only wolves are responsible for damages and never dogs (Boitani 2000; Reinhard and Kluth, own experience). For this reason it is appropriate to also compensate doubtful cases where all that can be said is that a canid killed the livestock (Boitani, 2000).

This is the practice in most of the surveyed regions. In Saxony assessment of damage claims now focuses mainly on the accurate use of preventive methods rather than on whether a dog or a wolf killed the sheep.

Preventing damages is better than refunding damages after they occur. Prevention is active and the only system that will help to diminish damages. Thus compensation has to be linked with preventive measures (Boitani, 2000). This statement seems to be true for Saxony although compensation has only been linked to prevention since 2008. After compensation was coupled to prevention, damages dropped considerably (see above). However, with the rapid spread of the wolf population into new areas this trend may become less obvious. Even if new wolf areas are adjacent to already established wolf territories livestock owners tend to respond to the presence of wolves only after the first damages occur.

Fencing seems to be a very simple method to prevent wolves from attacking livestock. However, due to fences of insufficient height, low electric power or fences that are not fixed to the ground the effectiveness of fences can be challenged. In such circumstance a wolf may quickly learn to overcome fences by jumping or digging. It is therefore necessary to keep fences properly maintained. Mobile e-fences have the advantage of excluding other wildlife only part time, while permanent fences may present a barrier for wild animals such as ungulates and constrain public access to the landscape. Permanent non-electric fences in wolf areas should be secured in a way that prevents digging under the fence.

Although most wolves do not jump, a single jumping individual can cause a lot of trouble. If an additional visual barrier, such as a white cord or fladry stretched over the fence, do not work it will likely become necessary to either use an additional protection method (e.g. LGD) or remove the wolf as is done in Sweden.

In many areas a combination of electric fences and livestock guarding dogs seems very effective. However, LGD programs need to be carefully managed to avoid problems with dogs being inefficient or overly aggressive towards people (Mettler and Lüthi, 2009; Ribeiro and Petrucci-Fonseca, 2005; Rigg, 2005; Smietana, 2005). In many areas livestock keepers have no traditional knowledge on the handling of LGDs. This knowledge has either been lost or has never existed (e.g. Germany, Scandinavia). In these

**Table 3** – Recommendations given for Germany for preventive methods for large carnivores (Reinhardt et al., 2010).

| Preventive methods | Useful against | | | Recommendations |
|---|---|---|---|---|
| | Wolf | Bear | Lynx | |
| Non electric sheep fence (fixed) | × | – | – | For small scale application (small flock) with protection against digging; min. 120 cm, better 140 cm in height. |
| Non electric fence for game enclosures | × | × | × | In wolf/bear areas with protection against digging; after lynx/bear attacks with protection against climbing over. |
| Fladry | × | – | – | As emergency measure after wolf attacks. |
| Permanent e-fence | × | × | × | 5 wires: 20, 40, 60, 90, 120 cm. |
| E-sheep net | × | × | (×) | With stiff vertical plastic mesh; when used without LGDs: 110 cm. |
| E-wire fence | × | × | × | 5 cords: 20, 40, 60, 90, 120 cm. |
| Livestock guarding dogs | × | × | × | Minimum 2 mature dogs per flock. |
| Livestock guarding donkey[1] | (–)[1] | (–)[1] | × | Only 1 mature donkey per flock. |
| Livestock guarding llama[2] | – | – | (×) | Not recommended. |
| Negative food conditioning | – | – | – | Not recommended. |
| Negative conditioning (with rubber bullets)[3] | – | – | – | Not recommended. |
| Acoustic and visual repellents | – | – | – | Not recommended. |
| Protection collars | – | – | – | Not recommended. |
| Shepherding | × | × | – | In areas with free ranging sheep (e.g. Alps) necessary for other preventive methods (LGDs and night time enclosures). |

[1] We recommend to test the effectiveness of livestock guarding donkeys in small flocks. For further informations on livestock guarding donkeys see Linnell et al. (1996) and Angst et al. (2002)

[2] For information on livestock guarding llama see Franklin and Powell (1993) and Angst et al. (2002)

[3] Useful to increase shyness of habituated individuals but not as preventive method.

areas shepherds need advice on the raising and training of LGDs. Simply providing them with dogs without any further support can create more problems than it solves. LGDs that are not properly raised and guided may become less trustworthy. Some dogs leave their flocks and chase game, or they may exhibit excessive play behavior and injure or even kill sheep. Others may become overprotective, showing aggressive behavior towards people or they attack dogs that are walked near the flock (e.g., Mettler and Lüthi 2009; LIFE - COEX 2008 Report Action D2; Reinhard and Kluth, own experience).

The return of the wolf to Germany after more than 100 years of absence is a challenge that to some people seems unfeasible. However, the first ten years have shown that the precondition for mitigating the livestock-wolf conflict is rather favorable in most regions of the country. The main conflicts have to be expected in the Alpine areas where livestock is commonly left unattended during the grazing period. Although experience from other countries shows that preventive methods can be effective in such areas (e.g. Espuno et al. 2004; Dalmasso and Orlando 2010), the necessary change of husbandry practice will usually encounter resistance. In the German Alps, some form of shepherding in combination with LGDs and night corrals will likely become necessary. In areas where livestock is kept in fenced pastures, such as in NE Germany, the improvement of these fences is less controversial and conflicts are usually lower.

## Recommendations for Germany

For Germany we recommend funding of preventive methods for small livestock only. Since depredation on cattle and horses is much less frequent in Europe (Kaczensky, 1996) and has been very rare in Germany to date, funding of protection measures for large livestock costs would presently outweigh benefits. Wild ungulates are abundant enough in many regions of Germany that the protection of small livestock will not force wolves to switch to large livestock. In Saxony funding for prevention measures is provided for livestock owners within the confirmed wolf area and an additional 30 km radius. For this approach an intensive monitoring is necessary. Wide areas of Saxony are densely populated (average population density 227 $km^{-2}$) making it unlikely to become re-colonized by wolves. Therefore costs and efforts are focused on areas actually inhabited by wolves. In contrast, Brandenburg (average population density 85 $km^{-2}$), expect its whole region to become populated by wolves. Funding of prevention measures is provided for the whole country and not linked to the actual area of occurrence. Most of the German Laender plan to or already follow the Saxonian model. Whatever approach is taken, we strongly suggest to link compensation for damages on sheep and goats to prevention.

## Lessons learned

- Damages caused by wolves cannot be reduced to zero, but they can be decreased considerably.
- Do not try to reinvent the wheel. There is already a lot of experience that may be used for areas with re-colonizing wolves. Not all is published, but colleagues from other countries will usually readily share their experience when asked.
- Since each farm is different the set of methods to be applied should be adapted to the concrete circumstances.
- A combination of electric fences and livestock guarding dogs is regarded as most effective.
- A constant support for LGD keepers is imperative and should be part of any preventive system, especially where LGDs are funded.
- Compensation should be coupled to prevention, especially if preventive methods are financially supported.
- In confirmed wolf areas the decision on granting compensation payments should be made by focusing on the correct use of preventive methods and not so much on whether the damage was caused by a wolf or a dog.

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