focused on prevention measures, including this type of enclosure as a recommendation for reducing wolf damage. We aimed to evaluate the efficacy of this system to prevent wolf predation on calves and to quantify the investment needed to implement this method, i.e. the extra investment needed for cows to learn to use the selective gates without the help of the farmer.

For detailed information on this type of enclosure visit the official web site of the Ministry at: http://www.magrama.gob.es/es/biodiversidad/temas/conservacion-de-especies/ce_silvestres_resolucion_lobo_bovino_tcm7-358441.pdf

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Short Communication

WOLF BEHAVIOUR TOWARDS ELECTRIC FENCES USED IN AGRICULTURE

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1. Introduction

In many regions of Europe, the return of large carnivores regularly leads to livestock damage. This results in discussions regarding risk assessment as well as implementation and financing of protection measures. Fences were previously used to contain livestock; however, electric fences are now also increasingly used as a relatively simple, low-cost method to protect livestock from predation.

Several studies have assessed the effectiveness of electric fences as a damage prevention measure (Cortés, 2007; Liere et al., 2013; Wam et al., 2004), but the behaviour of large predators when encountering such fences is still poorly understood. Some authors have concluded that canines, especially wolves, tend to crawl underneath fences (e.g. Bourne, 2002; Reinhardt et al., 2012). However, based on their personal observations, shepherds have reported that wolves are able to jump over fences, electrified or not, usually when sheep are penned during the night. Such claims raise crucial questions for livestock protection: How do wolves approach a fence and how do they succeed to cross it? Do strategies and behaviour vary between different individuals or packs? What is the role of social learning?

To address these questions a series of experiments was conducted in 2015 by AGRIDEA - Swiss Association for the Development of Agriculture and Rural Areas. The aims of the study were to:

1. gain knowledge about the behaviour of wolves towards three designs of fences that are used in Swiss agriculture;
2. study wolves' strategies to approach, investigate and cross fences;
3. gain insights into the way wolves take advantage of weak points in fencing systems.

2. Study animals

The experiments were conducted in the Sainte-Croix animal park (Rhodes, France) in autumn 2015 with two packs of captive wolves:

- Grey wolves (*Canis lupus lupus*): seven individuals (three males, four females); classic family structure with a well-established hierarchy; the parents were born in 2005 and the offspring in 2010 and in 2012;
- Arctic wolves (*Canis lupus arctos*): seven individuals (four males, three females); six siblings from the year 2014 and an older sister born in 2013.

All individuals were born in captivity, but were not socialized with humans. They showed a natural fear of humans and maintained a distance of approximately 8-15 metres from persons entering their enclosure. There were no neutered individuals in either pack.

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3. Experimental design

The grey wolves were kept in an enclosure of 0.87 hectares, while the arctic wolf enclosure was 0.64 hectares. The wolves were deprived of food for four days prior to the first experiment. Afterwards, meat (beef or poultry, as used for their regular feeding) was placed inside an electric fence for 72 hours. After these three days the wolves were fed normally before starting over with the next experiment. The electric fence was set up as a triangle to facilitate observation and recording: part of the wolves' normal enclosure was used for the two shorter sides and the longer side was formed by the experimental fence (Fig. 1). The length of the tested fence was about 45 metres in the arctic wolves enclosure and about 25 metres in the grey wolves enclosure.

Three remote cameras (in video mode) and two thermal cameras were used to record all experiments in their entirety (Fig. 2). In addition, one person in a hide with a handheld camera filmed the wolves' behaviour during the day. To avoid a "site effect" we investigated if wolves regularly used the experimental areas prior to the experiments. These observations confirmed that wolves frequently passed through the areas where the experiments were set up.

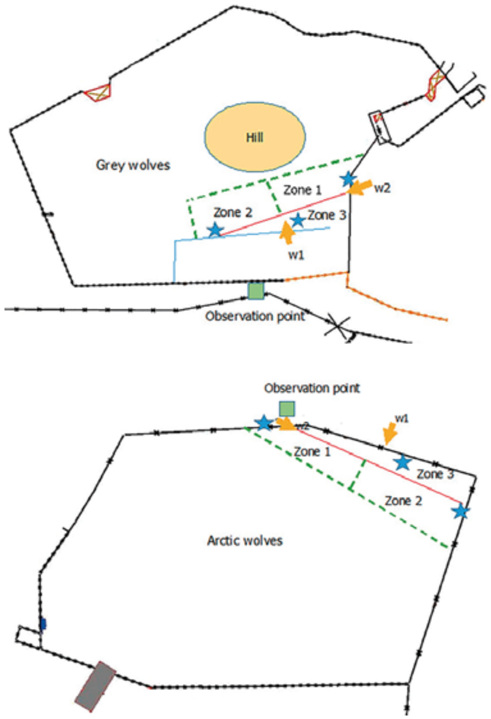


Fig. 1. Enclosures of the two wolf packs studied with indications of the experimental setting.
red line – experimental fence; **yellow arrows w1 and w2** – thermal cameras; **blue stars** – remote cameras; **blue line** – internal fence, non-electrified; **zones 1 and 2** – experimental areas under constant observation/recording by cameras; **zone 3** – area where food was placed during experiments.

Fig. 2. Installation of the camera equipment: remote camera (Bushnell, above) and thermal camera (AXIS Q1921-E, below).

Two designs of fences (Table 1) were tested alternately with each pack and a third design with the arctic wolves only, according to the following sequence:

Experiment 1: Flexinet (electrified net);
Experiment 2: fence with two wires (type A) (Fig. 3);
Experiment 3: Flexinet;
Experiment 4: fence with two wires (type A);
Experiment 5: fence with two wires (type B).

This last test was conducted with the arctic wolves only because construction works within the grey wolf enclosure did not allow completion of the final experiment as originally planned.

Fig. 3. Meat left during an experiment in the grey wolf enclosure. In this case, a two-wire fence was tested. A thermal camera and two remote cameras can be seen, fixed on wooden poles and facing towards the fence or meat.

Table 1. Designs and characteristics of the fences tested.

Fence design	Height (cm)	Colour	Tension (volt) / Amperage (Ø)
Flexinet	90	Orange	V: 3400 / A: 1.7
Fence with two electrified poly wires (type A)	Bottom wire: 25	White and red	V: 3600 / A: 2.0
	Top wire: 65	White and red	V: 3300 / A: 1.9
Fence with two electrified poly wires (type B)	Bottom wire: 35	White and red	V: 3600 / A: 2.0
	Top wire: 80	White and red	V: 3300 / A: 1.9

Voltage and amperage were measured immediately before the start of each experiment as well as afterwards using a Gallagher fence volt/current meter and fault finder (specifications: voltage: 0.2 to 10 kV; current: 1-35 A; battery: CR2032).

After each experiment, all equipment was removed and reinstalled for the next experiment. During the period between experiments wolves were free to roam in their enclosure, including the experimental areas. It can be assumed that the wolves already had some contact with electrified wires in the past, since some parts of their enclosures were additionally secured with one or two such wires inside. Unfortunately, nothing can be said about the details or number of such contacts with electrified wires. However, the fence material we used in our experiments was different from the electrified steel wire already within the enclosures. As far as we know the wolves had not encountered such material before.

Based on observations made during the day, an ethogram was compiled and continuously updated (Fig. 4). The behaviour "obs" was not recorded during the night because the data analysis was conducted by two different persons who carried out video-analyses using slightly different observation protocols. For each behaviour that lasted longer than 3 seconds (e.g. exploring the fence), its duration, frequency and associated posture (e.g. with self-assurance or with caution) was noted. For each behaviour that did not last 3 seconds (e.g. sniffing the ground), only the frequency was noted.

3. Results and discussion

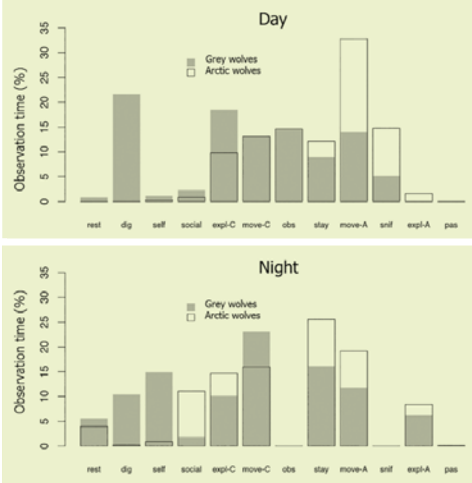
Throughout the experiments, none of the grey wolves and probably only two arctic wolves crossed the test fences. Neither pack attempted to jump over a fence.

The flexinet fence was crossed on three occasions by a single arctic wolf. It may have been the same individual each time, but we were not able to clearly identify individuals with the thermal camera. Due to the elasticity of the net, the wolf managed to pass with a somersault when it ran directly into the net. A wolf damaged the net while getting out and subsequently the fence was left lying on the ground. During the rest of this night the damaged fence was passed six times. This might be a critical starting point for a learning process in how to jump over fences. However, we were not able to investigate this hypothesis further.

The type A fence with wires at 25 cm and 65 cm was not crossed by any wolf. However, the type B fence with wires at 35 cm and 80 cm was crossed by at least two different arctic wolves that crawled under the lower wire a total of nine times. One wolf touched the upper wire with its nose and then rushed through the fence between the wires. On several occasions a wolf that had got inside brought a piece of meat close to the fence and other wolves took it out from the other side. Sometimes a wolf carried a piece of meat back across the fence.

During exploratory behaviour towards experimental fences the wolves' heads pointed mostly straight ahead or downwards (Fig. 5). This suggests that they scanned fences for weak points, particularly on the lower parts. In grey wolves, this tendency was more pronounced when exploring the wire fences than the flexinet-fence. The results with arctic wolves show almost no such effect of the fence design. Furthermore, the following behaviour pattern was generally found before a wolf crossed the fence: after an initial exploration of the fence by several members or the whole pack, social interactions noticeably decreased and the behaviour of the wolves seemed to change from predominantly cautious to a more confident behaviour until one individual crossed the fence. This may have involved habituation (non-associative learning).

In both packs, the frequency of wolf presence close to fences decreased over the three experimental days. Only during experiment 5, in which the bottom wire of the fence had been lifted to a height of 35 cm and a wolf crawled under several times, was the opposite tendency observed (Fig. 6). This suggests that motivation to approach and explore the fence declined over the 72 hours of our experiments if wolves were not able to cross it.



rest – resting;
dig – digging;
self – behaviour relating to the wolf itself such as cleaning, urinating, feeding, etc.;
social – social interaction;
expl-C – exploring the fence with caution;
move-C – moving with caution;
obs – looking in the direction of the fence or over it;
stay – standing around (for at least 3 seconds);
move-A – moving with self-assurance;
snif – sniffing the ground or other elements of the fence;
expl-A – exploring the fence with self-assurance (sniffing or observing);
pas – passing the fence (only occurred in the experiment with the arctic wolves).

Fig. 4. Total time that wolves were observed engaged in various behaviours by pack (grey vs. arctic) during the day and at night.

Fig. 5. An arctic wolf investigating the bottom part of a flexinet. The meat was placed on the left behind the fence.

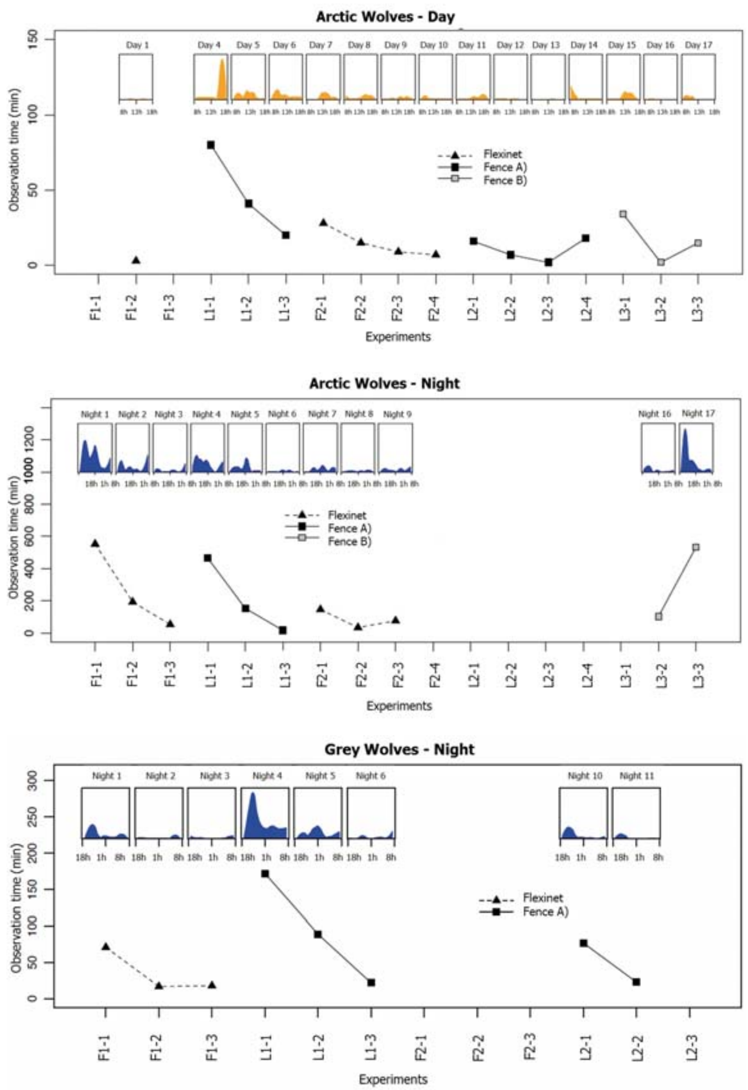


Fig. 6. Frequency of wolf presence at test fences as a function of each experiment for the arctic wolves during the day (top) and at night (middle) and the grey wolves during the night only (there were insufficient approaches to the experimental fence during the day to include in the figure).

F – experiments with the flexinet; L – experiments with a two-wire fence. The first digit corresponds to the order of the conducted experiments (1 – first time; 2 – second time) and the second digit corresponds to the number of days (top) or nights (bottom) within an experiment (e.g. F2-3 – second experiment with a flexinet, third night). Each experiment included three nights. For the observation time, each minute with wolf presence was summarized for all present wolves (e.g. 100 – one single wolf was present for 100 minutes or five wolves were present together for 20 minutes). In the boxes the distribution of wolf presence is shown as a function of daytime (orange) or night time (blue).

Our observations suggest there could be a correlation between the hierarchical position of an individual and the frequency of the presence of this individual close to the fence. In both packs, a dominant individual was often seen close to the fence (an arctic wolf female and a grey wolf male). However, a dominant female grey wolf was rarely observed near the fence. We did not observe a clear hierarchy among the male arctic wolves. In future research, it would be interesting to study the possible correlation between social status and frequency of exploration. Such data could help understand if and how the behaviour of pack leaders influences other members in their attempts to explore and pass fences.

Fig. 7. A remote camera image of two male grey wolves exploring and digging in front of a type A two-wire fence (top wire 65 cm and bottom wire 25 cm). The meat was on the right behind the fence.

In addition, we also observed clear differences between the two packs: the grey wolves were much more cautious while approaching the fences and tended to stay further from them than the arctic wolves. The latter generally showed more social interactions as well as more explorative behaviour, they more often approached fences during the day and they appeared more confident while doing so. On the other hand, digging in front of the fence was observed among the grey wolves (Fig. 7) but was rare among the arctic wolves.

Once a wolf crossed the fence, other members of the pack became much more focused on that individual. However, it was not observed during any of our experiments that a wolf copied the behaviour of passing the fence after having observed a pack member doing so. Nevertheless, there might be a potential to learn in this way.

4. Final considerations

The insights gained from this study contribute to understanding the behaviour of wolves towards electric fences. Since the experiments were carried out with only two packs of wolves, each of which showed different behaviours, the results should not be generalized. It would be useful to perform similar tests with other wolves in order to further investigate the diversity of behaviours among packs and individuals which could be of significance in their management. Furthermore, it should be noted that there may be considerable differences in the behaviour of captive versus free-ranging wolves. Nevertheless, our findings reaffirm the importance of fence design and invite further research with the aim of providing better information for livestock farmers to increase the effectiveness of predator-exclusion fencing.

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Short Communication

NEOPHOBIA IN CAPTIVE WOLVES EVOKED BY SIMPLE, LOW-COST DISRUPTIVE STIMULI

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1. Introduction

Greater numbers of grey wolves (*Canis lupus*) on the landscape can lead to an increase in the number of livestock depredations (Mech, 1995). A multiplicity of methods exists to prevent livestock depredation by wolves and other carnivore species (Shivik and Martin, 2000; Shivik et al., 2003). Lethal predator control techniques have rarely reduced depredation to an acceptable level, and their use is disfavoured by the public (Shivik et al., 2003; Treves et al. 2016). In addition, traditional non-lethal methods to control predation, such as predator-proof fences, livestock guarding dogs and aversive devices, can be expensive and may not be suitable for every situation.

Novelty (such as novel objects and sounds) can evoke fear in animals (Corey, 1978). In the context of livestock protection, novel elements placed on the landscape can lead wolves to temporarily avoid a problematic area, such as livestock pastures. For example fladry, long ropes with hanging strips of material, has been used as a virtual barrier which wolves tend not to cross (Musiani and Visalberghi, 2001). In case of continuous exposure to a particular object, however, animals usually habituate to it (Corey, 1978).

Predators' responses to low-cost deterrents have seldom been studied. Zarco-Gonzalez and Monroy-Vilchis (2014) studied the effectiveness of low-cost felid deterrents to reduce predation. The effect of fladry on wolves' behaviour and its effectiveness to reduce predation have been assessed (e.g. Musiani and Visalberghi, 2001; Musiani et al., 2003), but little is known about wolves' behavioural response to other low-cost sensory stimuli, including novel objects, sounds and odours. Exploring the effect of various sensory stimuli on wolves' feeding behaviour may help the development of stronger deterrents. The aim of our study was to assess the relative effect of several low-cost, novel sensory stimuli on the feeding behaviour of sub-adult, captive and naïve wolves.

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