Are virtual fences applicable in mountain pastures?

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Abstract

Fencing steep mountain pastures is time consuming and expensive. Consequently, these valuable grasslands are more and more abandoned. Virtual fencing (VF) is a promising technology to facilitate pasture management: animals wear GPS-collars emitting (1) audio tones (ATs) when reaching a digitally determined pasture boundary, and (2) an electric pulse (EP) when crossing it. We aimed at testing the adaptation of cattle to VF in mountain conditions. Thirty heifers were trained to VF in the lowlands and then divided into 3 independent groups during mountain grazing. Here, during 3 months, each group successively grazed 9 paddocks (6 virtual fenced, 3 wire fenced). We recorded the number of ATs and EPs per individual. The VF system worked reliably, but required careful handling when changing paddocks. During 83 days of mountain grazing, each animal received an average of 4.9±6.9 ATs and 0.3±0.7 EPs per day. These numbers were much lower when compared to the training period, indicating an effective learning by the animals. Only during days with special events occurring (e.g., wildlife presence) were ATs and EPs significantly increased. VF effectively kept the animals within the defined area. Therefore, if a 4G-GSM network is available, it can facilitate mountain pasture management.

Introduction

Virtual fencing (VF) is a promising technology, since it can potentially optimize grazing management and reduce the workload for farmers, especially in extensive conditions (Umstatter, 2011). In VF systems, animals wear a VF-GPS collar and physical boundaries are replaced by virtual ones, which are digitally set in a smartphone app. The collars emit an audio tone (AT) when the animal approaches the virtual boundaries, followed by a weak electrical impulse (EP) when crossing it. Although livestock have been shown to successfully learn the system under flat conditions (Campbell *et al.*, 2020; Colusso *et al.*, 2021; Lee *et al.*, 2009), no research has been carried out to assess its applicability under mountain conditions. In mountain pastures, VF is especially promising because fencing is much more laborious, due to the more challenging environmental conditions. Mountain pastures are steeper, larger, rockier, with more heterogeneous vegetation of lower forage yield and quality, and weather conditions can be harsher. This may also affect animal behaviour and spatial pasture use and thereby could impair the functionality of VF. Additional challenges may arise due to lower GPS/GSM coverage, which in turn reduces animal positioning accuracy and thus may have a direct impact on animal learning. Therefore, this study aimed to investigate whether (1) VF is applicable in mountain conditions and (2) animals can deal with VF under mountain conditions in a rotational grazing system.

Materials and methods

The study involved 30 female heifers (11.9±1.6 months old) from a conventional Swiss dairy farm in the canton of Vaud and was conducted between May and August 2023. Each animal was fitted with a VF collar (Nofence, Batnfjordsør, Norway). First, the heifers were trained to VF under lowland conditions (about 700 m a.s.l.). An electrically fenced paddock was subdivided by a straight virtual boundary placed in parallel to an outer electric fence. The training procedure was designed in several small sub-steps, over a total of 16 days to facilitate animal learning, according to the approach adopted by Hamidi *et al.* (2022). After this training period, the heifers were transported to a mountain summer pasture in the Swiss Pre-Alps (between 1300–1500 m a.s.l.), including flat and open areas as well as steeper topography with rocks, shrubs and trees. Vertical transhumance of heifers is a typical alpine management system. The outer perimeter of the farm was electrically fenced. Within this area, the summer pasture was subdivided into three electrically fenced paddocks (EF control) and six virtually fenced paddocks (VF treatment). Heifers were divided into three homogeneous groups of 10 animals each, balanced by age and breed. All groups grazed simultaneously on separate paddocks under a rotational system, where two groups always grazed a VF treatment paddock and one group an EF control paddock. Depending on the limiting factor of available forage, all groups were moved to their next paddock at the same day after, on average, 9 days (min. 7 to max. 14 days). This procedure was repeated until each of the three groups had grazed each of the nine paddocks once (i.e., six VF treatments and three EF controls per group).

We evaluated the learning success of heifers by analysing ATs and EPs recorded by the collars. Two different generalized mixed effect models (GLMs) were calculated, one with the number of ATs and the other with the number of EPs as dependent variable, respectively. For both models, the fixed factors considered were grazing period, day after paddock change, as well as their interaction, average grass height, and days with special events, i.e., a lynx prowling around the pasture, a group of deer grazing nearby or a neighbouring cattle herd breaking through the outer fence of their farm and joining the experimental group. Cow identity, nested into animal group, as well as days of the experiment, were considered as random factors.

Results and discussion

During training, the total number of stimuli per cow per day was 15.4±26.0 ATs (mean±SD) and 1.6±1.7 EPs. During mountain grazing, the animals received on average 4.9±6.9 ATs and 0.3±0.7 EPs per day. Thus, both the total number of ATs and EPs decreased clearly when the animals had learned the VF system. Moreover, learning success was reflected by the animals grazing along the virtual fence without crossing it; i.e., they received several ATs, but few EPs throughout the experiment. The results of the GLMs revealed significant associations between the number of ATs and EPs and the estimated coefficients of the average grass height and days with special events (Table 1). During mountain grazing, the odds of a high number of ATs and EPs decreased by around 1% ((1–0.99)×100) at higher grass heights (P<0.05), respectively. This indicates that the heifers tested the VF boundary more frequently with a decreasing amount of fodder. However, the animals respected the virtual boundary, as the VF system was still effective in keeping the heifers within their assigned grazing area. Moreover, there was a clear impact of days with special events (Table 1). On these days, the odds of a high number of ATs increased by about 103% (P<0.001) and those of EPs by about 391% (P<0.001) compared to days without special events. The number of ATs and EPs received by the animals did not significantly change over the course of the grazing periods, among days after changing the paddock or in the interaction of these two effects (Table 1).

Conclusion

The results of this trial emphasise that the heifers learned the VF after two weeks of training in the lowlands, as well as its application in mountain pastures. The probability of special events such as wildlife contact can be increased under mountain conditions, which may ultimately affect the number of VF stimuli received by the animals. However, the VF kept the animals reliably within the defined grazing zones throughout the whole grazing period.

Table 1. Results from the fitted generalized mixed-effects models with ATs and EPs as the dependent variables and the parameter estimates for the fixed effects of the models.

Predictor	**ATs**			**EPs**		
	Estimated coefficient	**Odds ratio**	**Significance level**	**Estimated coefficient**	**Odds ratio**	**Significance level**
Special event	0.707	2.03	***	1.592	4.91	***
Period	−0.061	0.94	ns	−0.128	0.88	ns
Days after paddock change	0.047	1.05	ns	0.078	1.08	ns
Average grass height	−0.008	0.99	*	−0.015	0.99	*
Period×Days after paddock change	0.009	1.01	ns	0.008	1.01	ns

Significance levels: ***$P<0.001$; *$P\leq 0.05$; ns, $P>0.05$.

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