Virtual fencing predictable for cattle? A simple method to test whether and how fast cattle can learn the association between acoustic signal and electric pulse

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Abstract

Virtual fencing (VF) offers promising future prospects for improved grazing management as it has the potential to simplify fencing. VF lines are easily drawn and shifted via GPS coordinates. A VF collar emits an acoustic signal when the animal approaches the VF line. The signal stops immediately when the animal turns around. If the animal continues to move towards the VF line, a short electric pulse is emitted. A teaching and an operating mode are provided by the VF collars. The animals automatically change mode when they respond correctly to 20 consecutive acoustic signals without receiving an electric pulse. A prerequisite for using the technology is the ability of the grazing animal to learn to predict the electric pulse, therefore we used the time until mode change (from teaching to operating) to evaluate the learning ability and speed of 16 Fleckvieh heifers equally divided into two groups. All heifers were naive to VF prior to the study (conducted 05.07-16.07.2021). On the first day, the two groups were equipped with VF collars (® Nofence, AS, Batnfjordsøra Norway) and assigned to two adjacent pastures. On day eight, the collars were deactivated for a short time and then activated to start in teaching mode again to analyze differences in mode change speed when they were naive to the technology or experienced. The animals remained on the same pasture after reactivation of the collars. We investigated the time to reach theoperating mode (Δ) for each consecutive round (days one and eight) and found a significant difference ($p<0.0001$). Average Δ was 49.32 ± 0.41 h and 2.31 ± 0.41 h for round one and two, respectively. The faster mode change speed of the second round suggested successful learning. Given our study results, cattle learned to predict (and avoid) the electric pulse of VF collars.

Introduction

The virtual fencing (VF) technology provides a fencing system for animals without using physical fences by replacing the visual cue with an acoustic signal. A prerequisite for using the VF technology without increasing the risk for animal welfare is that grazing animals learn to avoid the electric stimuli (Lee et al. 2008). The basic requirement for avoiding the electric pulse is to learn that the acoustic signal precedes it. Learning to adequately interact with the virtual fence was made possible in different previous grazing trials and resulted in no measurable deterioration in animal welfare (e.g. Campbell et al. 2019; Verdon et al. 2021a; Hamidi et al. 2022). To assess the learning capability the ratio of acoustic signals and electric pulses is calculated in some trials (Colusso et a., 2021; Verdon et al., 2021a; Confessore et al., 2022). However, a simple way that can easily be adopted under practical conditions is missing so far. To our knowledge, it remains an open question how fast cattle are capable of learning appropriate responses to the VF system and on what evidence the VF system is considered to be learned.

In this trial, we used the integrated mode change function of the VF collars (® Nofence, AS, Batnfjordsøra Norway) to analyze how fast cattle are able to learn to avoid electric pulses when they (i) are naive to the technology and (ii) have several days of experience with the virtual fence. We used the time taken to switch from the VF teaching to operating mode to evaluate learning success and expected faster mode change speed in round two for experienced vs. naïve cattle.

Material and Methods

The current trial was conducted on the experimental farm of the University of Göttingen in Relliehausen, Solling Uplands, Lower Saxony, Germany (51°46'48"N 9°42'15"E) on grass-dominated permanent pasture. We used the data of a 12 d VF training period (see Hamidi et al. 2022 for details) from 05.07-16.07.2021. For this, 16 Fleckvieh heifers, which had no experience with the VF-technology prior to the trial, were equally divided in two groups and equipped with ®Nofence VF collars. A teaching and an operating mode are provided by the VF collars from the manufacturer. In teaching mode, the animal only has to turn the head to stop the signal. Whereby in operating mode, the animal has to walk at least 2 m away from the virtual boundary into the pasture to stop the acoustic signalAnimals automatically change the mode after responding correctly to 20 consecutive acoustic signals, without receiving an electric pulse. On the first day, the two groups were assigned to two adjacent pastures. On day eight the collars were deactivated for a short time and then activated to start in teaching mode again (on the same pasture). We used the time until mode change to evaluate the learning ability and speed. Therefore, we investigated the time to change from the teaching to the operating mode (Δ) for each consecutive round (day one and eight). Statistical analysis was carried out with the software environment R (R Core Team 2022). Linear mixed effect models were calculated by using the package 'nlme' (Pinheiro et al. 2018). Values for Δ were regressed on the fixed effects of round (two levels) and pasture (two levels). The individual animal effect was modelled as a random term. Normality of the residuals was checked by visual inspection of quantile-quantile plots (according to Zuur 2009). Variance homogeneity was evaluated by plots of residuals vs. fitted values and residuals vs. predictor values. For a significant effect, multiple contrast tests according to Tukey's HSD test using Sidak's method of confidence level adjustment were conducted in the 'emmeans' package (Barton, 2018).

Results and Discussion

We found a significant effect of round ($p<0.0001$). In round one, Δ averaged 49.32 ± 0.41 h (estimated mean ± SE). The average Δ in round two was 2.31± 0.41 h (estimated mean ± SE) (Figure1).
The highly significant effect of round, as shown by the decreasing Δ between rounds indicated cattle successfully learned how to avoid the electric pulse.
The question of "if and to what extent the technology can be described as successfully learned?" is important in order to exploit the full potential of VF. Verdon et al. (2021b) recommended the use of an appropriate training period. Hamidi et al. (2022) have tested a 12-d training schedule with the focus on evaluating animal behavior to ensure that animal welfare is not negatively affected, but analyses of the learning speed and effectiveness havenot been performed so far. Considering the small value of Δ in the second round of this trial, a period of 12 days may appear to be quite long. However, Verdon et al. (2021b) canceled their first training protocol after a breakout but subsequently developed a functional three-day training protocol. It must be ensured during training that each individual animal learns the VF technology effectively by responding to the acoustic signal and avoiding the electric pulse. Mode change speed appears to be a suitable metric to prove if the cows have learned to anticipate and avoid the electric pulse in a simple way.

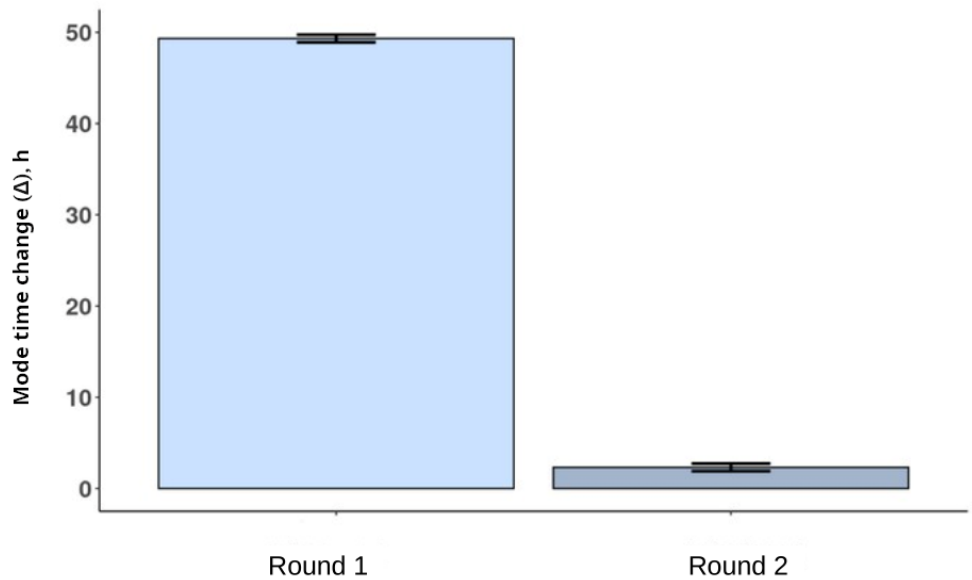

Figure 1: Comparison of means ± SE of time to switch from the teaching to the operating mode (Δ) on two consecutive rounds (Δ).

Conclusions

After having learned the system, cattle are able to anticipate and avoid t the electric pulse from the VF collars, which is visible by increased response to the acoustic signal (i.e., smaller Δ). Therefore, using the integrated mode change from teaching to operating mode to evaluate how fast cattle are able to learn to anticipateand avoid the electric pulse appears to be a promising approach for a simple way to analyze and ensure the learning success under a range of different use cases for VF. Future research is necessary to determine how long an appropriate training period should be to ensure effective learning for different breeds, grazing systems, etc..

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