Rotational stocking with virtual fences: effects on grassland diet digestibility, livestock performance and stress levels of heifers

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Abstract

Virtual fencing is an innovative technology for simplified, less laborious dynamic grazing management and remote animal monitoring. The effect of this novel technology on animal welfare is still a matter of debate. Previous research suggests no differences in stress experience responses of cattle between the two fencing systems on continuously stocked pastures. This study investigated differences in diet organic matter digestibility, livestock performance and fecal cortisol metabolite concentrations of heifers on pastures in a rotational grazing system, fenced with a virtual fence (Nofence, Batnfjordsøra Norway) compared to heifers fenced with a traditional electric wire fence. The study was conducted in 8 weeks from July to September 2021 using 32 heifers divided into four groups allocated to the two fencing systems (two replicates). The experimental pasture of each group was subdivided into four paddocks for rotational grazing. Fecal samples were collected the first day and last day on pasture of each rotation period. Grassland herbage samples were taken by hand plucking pre- and post-grazing and analyzed using near infrared reflectance spectroscopy. Heifers were weighed prior to and after each rotation. The results suggest that no differences occur between the two fencing treatments with respect to diet digestibility, livestock performance or stress level, pointing at no trade-off to livestock performance or animal welfare when using virtual fencing.

Introduction

Virtual fencing is an innovative technology for simplified dynamic grazing management and remote animal monitoring to reduce high labor requirements in pasture-based livestock production. However, the effect of this novel technology on animal welfare is still a matter of public debate. While previous research suggests no differences in stress responses between cattle on pastures using virtual fencing compared to standard physical fencing on continuously stocked pastures (Hamidi et al., 2022), little is known about the effects of virtual fencing on animal welfare and livestock production in rotational stocking management. Therefore, this study investigated differences in livestock performance, organic matter digestibility of the grazed herbage and fecal cortisol metabolite concentrations of heifers on pastures in a rotational stocking system, fenced with a virtual fence (Nofence, Norway) compared to heifers fenced with a traditional electric wire fence.

Methods

The study was conducted in July to September 2021 at the experimental farm of the University of Göttingen in Relliehausen, Solling Uplands, Lower Saxony, Germany. The trial was approved by the animal welfare service of the LAVES (Lower Saxony State Office for Consumer Protection and Food Safety (Germany) – ref. Number: 20/3388). 32 non-pregnant Fleckvieh heifers were randomly divided into four groups of eight animals each and allocated to one of two fencing treatments – virtual fencing (VF) or physical fencing with an electric wire (PF). Each fencing group was replicated twice. All heifers were equipped with Nofence virtual fencing collars (Nofence, Batnfjordsøra, Norway). The virtual pastures are created in the Nofence App. The Nofence collars communicate with the Nofence App via the cellular network and have a built-in GNSS receiver for location tracking. With the VF collars, animals are conditioned to associate an audio cue that marks a virtual border with an electric pulse that is triggered at the highest pitch of the audio cue in the event of an animal crossing that virtual border.

The heifers assigned to the VF groups were trained to the Nofence virtual fencing technology in a 12-day training period preceding the trial (Hamidi et al., 2022). The fence function was deactivated for the collars on the PF groups.

Each group was assigned to a 2-ha pasture that was subdivided into four rectangular paddocks. The resulting average stocking density was 14.4 ± 1.9 livestock unit (LU)/ha with one LU representing 500 kg live weight. Grazing took place in two 15-day periods. Per period, each group grazed in a paddock for 3 to 4 days before rotating to the next one. The available grassland herbage on offer was always sufficient to meet animal requirements to prevent uncontrolled escapes from the VF pastures. For the PF groups, a gate was opened between the current and the new paddock and closed immediately after the last animal had passed through. One person was required to open and close the physical gates and stood by the gate until all animals passed. For the VF groups, the virtual border was expanded to encompass both the current and the new paddock. After all heifers had passed into the new paddock – marked by a green, metal fence post – the virtual pasture was adjusted to encompass only the new paddock. One person adjusted the virtual pasture, standing at the border. After completing one full rotation in period 1, animals grazed on an area surrounding the experimental pastures for a 20-day break. In period 2, the same procedure of a 15-day grazing rotation was replicated, with all groups being assigned the same experimental pastures as in period 1.

Animal live weight gain (LWG) was calculated as the difference in live weight measured on the first and last days of grazing in each period. Fecal samples were collected on the first day and the last day of grazing in each period for analysis of i) fecal nitrogen (N) concentration and ii) fecal cortisol metabolites (FCMs; Palme et al. 1999). For each animal, up to three samples were collected on pasture immediately after spontaneous defecation. Samples were cooled immediately after collection and frozen for storage (−18 °C) within eight hours after sampling. The FCMs were extracted from the defrosted fecal samples according to Palme and Möstl (1997). For this, a portion of the wet feces (i.e. 0.5 g), suspended in 5 mL of 80% methanol, was shaken and centrifuged and fecal cortisol metabolites were measured in an aliquot of the supernatant via an 11-oxoetiocholanolone enzyme immunoassay (EIA, Palme and Möstl, 1997). The FCM concentrations in the feces reflect the cortisol secretion in the body approximately 12 h earlier (Palme et al., 1999). Additionally, fecal samples were dried at 60°C until constant weight. Thereafter, a subsample was burned in a muffle furnace to determine the organic matter content. Another subsample was analyzed for the total N content using elemental analysis (Vario el Cube, Elementar Analysensysteme GmbH, Langenseibold, Germany). Digestible organic matter (DOM) content was determined from the fecal N concentration after Schmidt et al. (1999). Grassland herbage quality was determined from hand-plucked samples taken pre- and post-grazing in the relevant paddocks. For this, three samples consisting of 5-10 manual hand pickings mimicking cattle grazing behavior, were obtained in each paddock (plucking the upper half of the extended sward height). Samples were frozen before analysis. The fresh matter was determined after thawing. Then samples were dried (60°C, 48 h), milled in a two-step procedure (first 4-mm and then 1-mm) and then analyzed with near-infrared reflectance spectroscopy (NIRS) on a Phoenix 5000 (BlueSun, USA) to determine *in vitro* organic matter digestibility (IVDOM) according to Loza et al. (2021).

All data analyses were performed in R Studio (v2022.07.2; R Studio Team, 2020; R Core Team, 2021) using the packages “nlme” and “emmeans”. Data analyses were performed using a one-factorial linear mixed effects model with the fixed effect of fencing system (LWG, DOM, IVDOM), a two-factorial analysis with the fixed and interaction effects of fencing system and sampling day (FCM). In the model for comparison of IVDOM and DOM, replicate nested in period, nested in paddock served as random effect. The animal ID nested in replicate, nested in period was included as random effect in the models of FCM and LWG. Comparisons of means followed post-hoc using Tukey’s HSD test.

Results and Discussion

The FCM concentrations did not differ ($p>0.05$) between fencing systems (estimated mean for both treatments = 43.4 ng FCM/g feces). However, a difference ($p<0.005$) was recorded between sampling days with overall decreasing FCM concentrations over time (Table 1). Similarly, Hamidi et al. (2022) found no difference in FCM concentrations when comparing VF to PF, but they reported lower FCM concentrations of 14.3 and 16.4 ng/g feces for VF and PF, respectively, on continuously stocked pastures. This suggests that in our study, under rotational grazing with frequent changes between paddocks and more human interaction, the animals experienced some stress. However, this was unrelated to the new technology of virtual fencing. Significantly lower FCM concentrations towards the end of period 2 compared to the end of period 1 suggest that the animals adjusted to the management during the trial. Correspondingly, the significant increase in FCM concentrations from first sampling at the beginning of period 1 to the second sampling at the end of period 1 suggests that the change in location and management style affected animals more than the fencing system.

Table 1: Estimated mean (emmean) in ng/g feces and standard error (SE) of fecal cortisol metabolite concentration of grazing heifers. Lowercase letters refer to differences among days ($p<0.05$).

sampling time	emmean	SE	group
start of period 1	48.8	3.26	a
end of period 1	63.1	3.86	b
start of period 2	37.4	3.16	a
second rotation period 2	39.3	3.64	a
end of period 2	37.4	3.21	a

Regardless of the fencing system, organic matter digestibility (DOM) was higher in fecal samples, with an average values of 72.1 % ± 2.5 for VF and 71.5 % ± 2.2 for PF, compared to the herbage IVDOM of on average 70.8 % ± 4.1 for VF and 70.5 % ± 3.6 for PF (Table 2) (estimated means ± standard error). This resulted in ratios of IVDOM to DOM of 0.98 and 0.97 for VF and PF, respectively, which suggests a difference in quality between the herbage on offer and the ingested herbage due to selection by the heifers (Table 2). These values could also mirror less efficient selection by humans compared to cattle. Nonetheless, Isselstein et al. (2007) found similar values using the same sampling method.
No difference ($p>0.05$) was found in IVDOM or DOM between fencing systems. Further, the fencing system did not significantly affect LWG, suggesting no effect of virtual fencing on livestock performance. The average daily LWG was 0.51 ± 0.37 kg/d and 0.85 ± 0.37 kg/d (estimated mean ± standard error) for VF and PF, respectively.

Table 2: The average and standard deviation of digestible organic matter in feces (DOM) in percent, in-vitro digestible organic matter in hand-plucked vegetation samples (IVDOM) in percent and the relative comparison (IVDOM/DOM) for two fencing systems, virtual fencing (VF) and physical fencing in two grazing periods.

	DOM %		IVDOM %		IVDOM/DOM	
fence	average	SE	average	SE	average	SE
PF	71.9	1.23	69.7	1.49	0.97	0.02
VF	72.5	1.23	70.8	1.51	0.98	0.02

Conclusions

Under rotational grazing management with frequent changes between paddocks for stocking, virtual fencing did not affect animal welfare and livestock performance in terms of fecal cortisol metabolite concentrations, live weight gain, and herbage selection differently from physical electric wire fencing.

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