Cattle (Bos taurus) behaviour and cortisol responses to electric fence and virtual fence in semi-natural pastures

Including Swedish farmers' views and attitudes towards electrical fence and virtual fence technology

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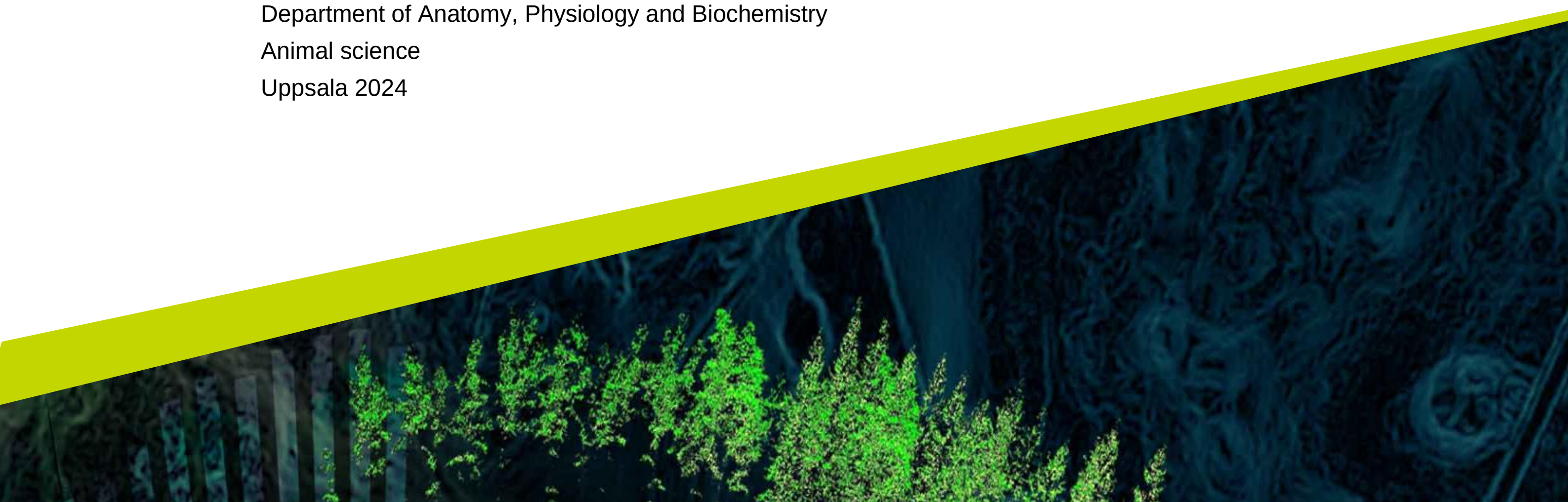

Cattle (Bos taurus) behaviour and cortisol responses to electric fence and virtual fence in semi-natural pastures. Including Swedish farmers’ views and attitudes towards electrical fence and virtual fence technology

Nötkreatursa (Bos taurus) beteende- och kortisolreaktion när de introduceras till elstängsel och virtuellt stängsel på semi-naturlig betesmark. Inkluderat svenska lantbrukares åsikter och attityder till elstängsel och virtuell stängselteknik

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1. Abstract

Virtual fence technology (VFT) that allows grazing livestock to be controlled without physical barriers, is a hot topic in today's farming industry. Several nations such as Norway, Australia, the United Kingdom, and Spain have legalised the practice, but Sweden has not yet done so. The Swedish Board of Agriculture, which is in charge of deciding whether to change the legislation to allow virtual fence (VF) technology in Sweden for commercial use, has asked for more research to be carried out in Sweden to learn more about whether and how VFT affects animal welfare, with an emphasis on inter-individual variation.

The project's main aim was to assess the behaviour and cortisol responses in two groups of 12-month heifers when released in a pasture with an electrical fence (EF) compared to when a VF was activated five days after pasture release. For 12 days, the effects of two treatments on seven heifers each were compared in semi-natural pastures in Uppland, Sweden. All animals were naïve to grazing, EF and VF. The treatments were: (a) transport and pasture release with a physical electrical tape fence from day 1–12, and (b) transport and pasture release with a physical EF day 1-5, and one VF border and three physical EF sides for day 6-12. The VF-collars were used in both groups that registered each individual's activity level, and the total number of pulses was collected through the collars to assess the treatment's impact. Additionally, faeces samples were taken from both groups before and during the study to measure faecal cortisol levels. The cattle in the VF group received electrical pulses for the first two days after activation of the VF. From day 1 (mean 10) to day 2 (mean 3) there was a decrease in amount of received pulses. Within two days of the virtual border being activated, two members of the VF group were excluded because they had achieved the study's endpoint for the number of pulses. No individually significant variations in the quantity of pulses were noted for the remaining members of the VF group. The cortisol levels in both groups showed significant differences between the groups VF and EF, but none between individuals within the groups. There were also some significant differences in activity levels between VF and EF on the majority of the days after the VF border was activated.

The experiment's second goal was to obtain information about Swedish farmers' attitudes (n=79) and concerns about EFs and VFs for managing grazing livestock. The findings show that the majority (52%) are not satisfied with their electrical fence, they stated that it was laborious in time to put up new fences and maintenance of the fence (72%). Furthermore, most respondents (60%) were inclined to incorporate VFT in their practice, and the majority (62%) stated that this would enable them to graze bigger areas than they presently can.

Keywords: activity, behaviour, cattle, cortisol, electric fence, farmers, stress, virtual fence, questionary

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Abbreviations

Ah	Ampere-hour
ANOVA	Analysis of Variance
DS	Standard deviation
EF	Electrical fence
EST	Eastern standard time
EU	European Union
RISE	Research Institutes of Sweden
FCM	Faecal cortisol metabolites
GPS	Global Positioning System
Ha	Hectare
kV	Kilovolt
LS	Least-squares
m	Meter
mW	Megawatt
ng	Nanogram
No	Number
s	Second
SBA	Swedish Board of Agriculture
SLU	Swedish University of Agricultural Sciences
TM	Trademark
TME	Treadmill exercise
VF	Virtual fence
VFT	Virtual fence technology
YBP	Years before present

2. Background

According to Swedish animal welfare protection legislation, it is not allowed to use any electrical equipment or devices to control the movement of animals, with the exception being physical electric fencing outdoors. It is essential for effective livestock management to have the ability to keep animals in certain regions and keep them out of others (Umstatter et al. 2015). However, there is limited information on what effects electric fences (EF) have on cattle regarding their behaviour and stress responses, especially what the physiological responses are when let out on pasture with an electrical fence. The building of physical fences in particular locations is not always possible, or not cost-effective for extensive systems, and then virtual fence technology (VFT) could be an alternative. However, further research is required to determine the behavioural and psychological reactions of animals to virtual fences (VF). Animal welfare regulations are not going to be addressed in this study; rather, they will be briefly referenced in the background section to help the reader better understand the current situation in the European Union (EU) and Sweden.

2.1.1 European Union

The Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes sets the minimum standards for the protection of all farmed animals in the EU. Furthermore, there are specific directives addressed to species and the protection of individual animals (European Commission 2023a), but there is no specific EU legislation for cattle. Instead, the addition of the Council of Europe Convention, the European Convention for the Protection of Animals Kept for Farming Purposes (ETS No. 087) has been ratified by the EU which in turn now a part of Union law (European Commission 2023b). The Convention covers animals that are produced or kept for the purpose of producing food, wool, skin, or fur, as well as for other agricultural uses. To ensure animal welfare, the convention requires parties to inspect the condition and state of health of animals, as well as the technological equipment used in intensive stock-farming operations. In article 4 of the treaty, it is stated that there should not be any restrictions on freedom of movement so that it causes unnecessary suffering or injury. In addition, the freedom of movement ought to be compatible with the requirements of the species as well as with well-established knowledge and experience (ETS No. 087).

2.1.2 Sweden

The Swedish Animal Welfare Act (2018:1192) and the Swedish Animal Welfare Ordinance (2019:66) regulate the use of electric devices on livestock in Sweden. It states that it is not allowed to use electrical devices to control the movement of animals (2:nd Ch. 16 § (2019:66), with the exception of outdoor pastures with physical electrical fences. The fence for cattle should be properly set up so the animals inside the pasture cannot hurt themselves on the fence (The Swedish Board of Agriculture’s regulations and general recommendations on cattle husbandry in agriculture etc., 6:th Ch. 1 § SJVFS 2019:18, Case No L 104). Virtual electrical fences are not mentioned in Swedish animal welfare legislation. According to PhD-student Lotten Wahlund at the Swedish University of Agricultural Sciences and Research Institutes of Sweden (RISE), that have had discussions with the Swedish Board of Agriculture (SBA), it is stated that VFT is included under the description of an electronic device that could be used to alter animals’ movement with electric pulses, hence that it is forbidden (Wahlund, 2021). Furthermore, SBA has the mandate to allow virtual fencing, but they have requested more scientific studies conducted in Sweden before they can take a stance regarding whether to allow virtual fencing for practical and commercial use or not. More specifically they would like more research on the learning capacity, stress level, and welfare of individuals subjected to repeated electric pulses as it is scarce when it comes to virtual fences. Additionally, they stated that there isn't enough research comparing virtual fences to traditional EFs to determine their long-term impacts.

3. Fences for livestock on pasture

3.1 History

The definition of a fence is a structure used as a fence, barrier, or border that is typically built of posts or stakes connected by boards, wire, or rails (The Free Dictionary, 2023), this will further be called a conventional fence. All domesticated livestock's ancestors once had unrestricted movement. To keep animals out of areas meant for cultivated crops as domestication progressed, certain areas were walled in with wood or stone (Sprott, 1995). Between 8000 and 10,000 years before the present (YBP), livestock was domesticated according to fossilised records (Holl, 1998). By anchoring them or creating a solid barrier, animals were kept in their enclosures. The earliest and most basic types of nomadic domestication permitted cattle to forage in open spaces during the day, but at night the animals were corralled in cages to keep them contained and safe (Holl 1998). In the beginning, livestock had to be herded on foot or on horseback which is still a common practice in some parts of the world (Campbell et al. 2017). The practice of enclosing land with a type of fence material has a long history. Many various kinds of enclosures have been built as a result of the desire for ownership, independence, and protection against interference from humans and predators. These psychological and financial ambitions were expressed in stone walls and rail fences. The types of materials that were accessible heavily influenced the design of these early barriers (Hayter 1939). One of the most expensive things associated with grazing livestock is fencing Mayer & Olsen 2005). When the stone and timber sources became insufficient, experiments with various types of materials, such as hedgerows, mud and ditch enclosures were developed. At first traditional fences such as stone walls and rails predominated until the less expensive smooth wire fence was created in the early nineteenth century (Hayter 1939). Due to the continuous decline in the amount of grazing in outfields since the Second World War, farmers have increasingly stopped using traditional fencing (Austrheim et al 2008). This is indicative of a structural concentration tendency with fewer, larger farms, but it is also a result of a political economy with expensive and in-demand workers (Vik 2020). As a result, many fields and pastures are not used for production anymore (Søraa & Vik 2021).

Nowadays fencing is commonly used to contain herbivores at pasture, additionally to keep them from overgrazing or undergrazing a certain area (Lomax et al. 2019).

3.2 Electric fences

Electrical pulses are frequently employed to control the behaviour of cattle, often because it is cheaper to have EF than conventional fences. For instance, electric fencing is frequently used to keep cattle in a pasture and in some nations, electric prods are employed to help drive cattle into trucks or through livestock chutes (McKillop & Sibly 1988). In today's modern livestock system, temporary or fixed EFs are frequently implemented for grazing livestock in the pasture (Anderson 2007). Electrical fences can offer flexibility, but they are sometimes impractical to inspect frequently and require a lot of time and labour to install and maintain. For more effective grazing, an automatic strip grazing system could be applied for the producer to replace the EF quite regularly in small, easily accessible areas (Campbell et al. 2017).

It is widely accepted that EFs emit electrical pulses (Hamidi et al. 2022). For an EF to effectively administer an electric pulse, electric fencing requires a power input that can deliver enough energy at the point of contact (Animal Welfare Committee 2022). Furthermore, elements like fence length, wire type, return earthing effectiveness, vegetation near the fence, and wetness all work together to potentially lessen the energy and, thus, the force of the pulse that is given. Depending on several factors such as breed, sex, age, season, management practices, which body part touches the fence, as well as the thickness and moistness of the coat or wool, the experienced voltage of the electric pulse may differ (Animal Welfare Committee 2022). For the animal to prevent electric pulse, EF-controlled cattle learn to stay away from the wire (Markus et al. 2014). However, an animal may receive repeated pulses if it entangles itself in an EF that is in use (Animal Welfare Committee 2022). According to Markus et al. (2014), training takes place as the animal learns to connect a particular cue, like the sight of an EF wire, with discomfort. The training is based on escape and avoidance conditioning. According to McKillop and Sibly (1988), cattle that are conditioned to electric fencing beforehand are less likely to touch the wire surrounding pastures. The study emphasizes the need to make sure that power is maintained on fences for the first week of fence construction. However, according to McDonald et al. (1981) social interaction and group learning are crucial to consider when cattle are trained on EFs to accustom the whole group. Additionally, the authors highlighted the importance that the EF must have power continuously, or cattle will push through an EF when the electricity is cut off. There is however a big lack of knowledge regarding the impact of electric pulses when cattle first learn to interact with an EF. Martiskainen et al. (2008) carried out a study on young calves regarding learning time to avoid electric fences before releasing them to pasture. They counted the number of electric pulses calves received from various kinds of electric fences over seven days. During the first day, the calves received an average of 18 electrical pulses, on day two the average number of pulses was six, followed by four on day 3. Furthermore, no research has been done so far on the quantity of pulses released throughout an entire pasture season. This is something that further needs to be researched.

3.3 Virtual fences

A VF is an invisible structure that acts as a border, enclosure, or obstruction without a physical obstruction and the borders can have any geometric shape (Sattarov et al. 2019). The technology was first used in 1987 to manage livestock (Fay et al. 1989). Global Positioning System (GPS) technology is used for virtual fencing through collar devices worn by each animal. The collars generate an audible tone as animals approach the pre-designed VF line, if they go beyond it, they experience an electrical pulse (Campbell et al. 2017) but if the animal stops or turns around, they do not receive a pulse (Lomax et al. 2019). To prevent an electric pulse, the cattle must learn to connect the sound with approaching the VF limit and to react only to the conditioned stimulus (Campbell et al. 2017). One of the world's leading companies in VFT is Nofence, the technology is executed by putting a collar on each animal, the collar which can deliver low-energy electric pulses if the animal crosses the VF limit (0.2 J, 3 kV, 1.0 s) after audible warnings (82 dB, 1 m) (Stampa et al. 2020).

VF systems have been known to use sensory signals, most frequently sound and electrical stimulation to alert an animal when it is getting close to an unseen radio frequency border. Today, the necessity for ground-based Radio frequency transmissions is replaced by radio signals coming from satellites, as those from the GPS (Anderson et al. 2009). According to preliminary research by Anderson et al. (2009), free-ranging cows can be managed by virtual systems that only emit an audio tone. Through sensory signals, control of the animal’s behaviour is achieved (Abdouna et al. 2023). According to prior research (Howery et al. 2014), cattle respond to stimuli that are visual, audial, and olfactory cues. It has been observed that cattle movements can be effectively managed through the use of cues. (Bishop-Hurley et al. 2007; Lee et al. 2009; Markus et al. 1998; Quigley et al. 1990).

VFT are a subject that comes up frequently in conversations about managing free-ranging livestock. It is particularly intriguing since it has the potential to improve management in several ways, including ecological management,

management by converting manual labour into cognitive labour, and livestock managers' quality of life. All these factors have the potential to lower costs for the animal owner. Additionally, this provides the opportunity for managing areas that are currently unmanageable (Umstatter 2011). This technology and management could have beneficial effects regarding rewilding, ecosystem services and habitat conservation, something that the EU displayed intention to support in the Horizon Europe 2030 program (Sonne et al. 2022). It is a constant struggle for producers to maintain good management of grazing livestock. The ongoing pursuit for greater animal productivity and optimum use of the space and resources at hand might be hampered by huge geographical regions and limited animal contact. In cases where installing physical fences is not feasible, the automated technology "virtual fencing" offers a possible alternative (Campbell et al. 2017).

3.3.1 Learning virtual fence technology for cattle

Previous research has demonstrated that sheep and cattle using VFT can be taught to respond to audio signals and thereby avoid electric pulses (Bishop-Hurley et al. 2007; Goonewardene et al. 2000; Hamidi et al. 2022; Hayter 1939; Lee et al. 2008; Lee et al. 2009; Markus et al. 1998; Markus et al. 2014;). In a study by Markus et al. (2014), no attempt was made to enter an exclusion region that had a VF border after day 2 of the trial. This coincides with a study by Quigley et al. (1990), which showed that steers could be learned to avoid an area managed by a fenceless system in less than two days. According to Aaser et al. (2022), animal welfare in virtual electrical enclosures is comparable to that of actual electric fencing. The authors furthermore state that the term "animal welfare" predominantly refers to an animal's fundamental health and functionality in connection to that animal's behaviour. Furthermore, the article states that in comparison to present approaches, such as physical EF, virtual fencing has no detrimental effects on animal welfare when they looked at several parameters such as learning ability, inter-individual differences, herd behaviour, reactions to electric pulses and distribution within the virtual enclosure. However, several of these studies observed cattle as a group and found significant inter-individual diversity, urging further studies that consider these differences (Campbell et al. 2018; Lee et al. 2009; Lee et al. 2018; Lomax et al. 2019; Verdon et al. 2020).

In a study by Aaser et al. (2022), they evaluated how well Angus cows (n=12) could be contained within a virtual enclosure by using Nofence technology. The study looked at the individual differences between the cows as well as the behaviour of the herd while responding to virtual fencing and training to do so. Additionally, the study examined the cows' activity as a welfare indicator. During the experiment, every cow was expecting a calf and calved during the study. A physical electrical fence surrounded the whole perimeter of the approximately 6.5-hectare enclosure. The southern physical fence line was taken down after two days and replaced with a virtual border, at which point the experiment started. After another six days, this border was subsequently shifted roughly 20 meters to the south. The border was then twice, after three days each, shifted forward 20 meters. The cows were permitted to roam freely within a 14-hectare virtual enclosure on day 14 of the experiment when the final three sides of the physical EF were removed. Throughout the 139-day period, seven breakouts occurred. The cows were exposed to the electric pulse for the first time on the first day of the experiment. Four of the breakouts could not be attributed to unfavourable circumstances. Eight cows once escaped because of a social panic reaction, and twice all twelve cows escaped. When the cows attempted to cross the ditch the second time, the virtual border had been put directly across from them. As a result, when the cows attempted to cross, they received an electric pulse in the middle of their attempt, leaving them with no choice except to move forward and out of the enclosure. To stop such accidents, the border was shifted. When a reporter flew a drone low over the herd and immediately above it, the herd finally stampeded. The mean value for the first 14 days was 4.2 electrical pulses, ranging from 3-5 per individual. However, the article also implies that personality and herd structure should be considered when choosing individuals for virtual fencing. Individual variations in behavioural characteristics that are consistent over time and in various circumstances have been defined as traits of an animal's personality (Stamps & Groothius 2010; de Azevedo & Young 2021). The authors in the article by Aaser et al. (2022) supports the promise of virtual fencing as a workable substitute for actual EF. Furthermore, the authors pointed out that it is evident that an individual receiving an electric pulse elicited a social response from its herd mates, as suggested by earlier research and validating the initial idea. These findings support prior research (Bishop-Hurley et al. 2007; Umstatter et al. 2015; Campbell et al. 2020; Langworthy et al. 2021) and highlight the potential for virtual fencing in livestock management. Additionally, there were no discernible alterations in the cows' level of activity following an electric pulse, indicating that receiving an electric pulse will have no long-lasting impact on the cows' level of activity. Staahltoft et al. (2023) evaluated the efficacy of virtual fencing for bull calves in a rotating strip grazing regime and found no correlation between summed activity and summed pulses. Based on activity measurements related to the cows' behaviour, this suggests that the virtual fencing system did not have a negative influence on the welfare of the cows (Aaser et al. 2022). Similar findings were made by Campbell et al. (2017) regarding the virtual border's minor influence on cow behaviour. In previous research by Lee et al. (2009) when manual remote-controlled Fleck™ collar devices were placed on Hereford they were effectively restricted from accessing a feed trough by responding to an audio cue alone, if the heifers did not respond to the audio cue, they were given an electric pulse. There was a high variation between individual animals in their rate of learning and the behaviours they exhibited in response to both the audio and electrical stimuli. This is aligned with several other studies, as they found significant inter-individual variance, urging further studies that consider and focus on that matter (Campbell et al. 2018; Lee et al. 2009; Lee et al. 2018; Umstatter et al. 2015; Verdon et al. 2020).

Keshavarzi et al. (2020) investigated whether cattle react to conspecific behaviour during their initial contact with a VF over three days. Sixty-four Angus steers were used, all of which were naïve to VF. The authors stated that little is known about how social factors affect how well individuals learn to react to VF indications. The purpose of their study was to ascertain whether cattle reacted to conspecific behaviour during their initial interactions with a VF over three days. They concluded that cattle remained within the inclusion zone based on conspecifics' responses, including some social effects on individual rates of associative learning between the audio and electrical cues.

3.3.2 Public and consumers' attitude towards virtual fence technology

Stampa et al. (2020) explored how virtual fencing in the meat and dairy industries was perceived by German customers. They used information booklets with several points of reasoning and used concurrent think-aloud methods to examine German customers' reactions. The study revealed that the respondents were unsure about VFT application in terms of its potential social influence and impact on animal welfare. With their purchase choices, respondents demonstrated their willingness to support pasture grazing, but they had trouble seeing how using a particular grazing management technique would benefit them personally. The authors furthermore urged that practitioners should think about keeping the emphasis in consumer communications on real benefits rather than technology, such as the quality of pasture-raised products. Additionally, it is claimed that official assistance is required to persuade livestock professionals to use virtual fencing in cattle grazing for biodiversity conservation.

At the time that this study was undertaken, there had only been one published scientific study on farmers' perspectives on VF. A study by Brier et al. (2020) investigated the opinions of farmers and researchers in New Zealand using the Delphi method, a method for acquiring expert opinions through numerous rounds of surveys. The article lists the primary advantages and disadvantages of VF as well as the moral dilemmas that should be considered. The main benefit was identified as environmental protection, which may have an impact on the environmental issues that pasture-grazed farming systems in New Zealand are currently facing.

Other factors, such as better feed distribution and labour cost savings, were identified as possible benefits. The two primary obstacles to the successful deployment of virtual fencing, according to the survey respondents, are technical functionality and value proposition. The community's opinions of poor outcomes for animal welfare were seen as a source of socio-ethical concerns, which were seen as a major obstacle to the implementation of VFT.

Due to concerns about animal welfare and the fact that physical fencing not only encloses animals but also restricts public access to these locations, it is a hotly debated matter (Crump et al. 2019; Maier & Shobayashi 2001; Plieninger et al. 2013; Van den Pol-van Dasselaar et al. 2020). However, especially when implementing virtual fencing systems in conservation grazing and rewilding programs (Maier & Shobayashi 2001), public concern about animal welfare is a hurdle. Crump et al. (2019) also state that animal welfare scientists and dairy consumers are concerned that full-time housing impacts cattle welfare negatively, as dairy cows in Europe and the US are increasingly kept indoors all year round. Even cows that have access to pastures are typically kept indoors throughout the winter and during calving. More studies are needed to promote virtual fencing, enable the use of nature, and safeguard and manage ecosystems and biodiversity, according to the study of these issues regarding recreation and biodiversity (Sonne et al. 2022).

4. Cortisol

4.1 Function of cortisol

The definition of stress can simplified be put that it is the physiological response when an individual feels as though there is a danger to its homeostasis (Minton 1994). When the hypothalamic-pituitary-adrenal axis is activated, it causes a cascade of endocrine responses that aid in stress management (Minton 1994). In reaction to a stressor, the hormone cortisol is released, which helps to mobilize energy and maintain homeostasis (Lee et al. 2008). The adrenal cortex produces and releases the typical mammalian stress hormone cortisol into the bloodstream. Adrenocorticotropic hormone, which is secreted by the pituitary gland in response to corticotropin-releasing hormone from the hypothalamus, controls it through negative feedback (Van der Kolk et al. 2016). Stress generates an increase in adrenocorticotropic hormone through the nervous system, which in turn boosts the adrenals' ability to produce and release cortisol. The cortisol-enhanced stress response affects a variety of biological processes, including the deamination of amino acids for gluconeogenesis and the mobility of glucose. Additionally, cortisol promotes fatty acid mobilization. All these actions work to increase the amount of fast energy that is available to muscle and nerve (Ndibualonji et al. 1995). Animals' stress responses are controlled by the hypothalamic-pituitary-adrenal axis and run by glucocorticoid metabolism. Following activity, cortisol is subsequently eliminated from the bloodstream through liver uptake, conjugation, and excretion via bile. Because cortisol is expelled through the bile as glucuronide or sulphate metabolites, there aren't many free cortisol molecules in cattle faeces (Ebinghaus et al. 2020). For this reason, faecal cortisol metabolites (FCM) have gained popularity as a tool for measuring stress in a variety of animal species among academics and environmentalists (Ebinghaus et al. 2020; Keay et al. 2006). Different animal species have varying baseline cortisol levels and cortisol levels in response to stress. The levels of circulating cortisol typically follow a diurnal rhythm, peaking between 8-9 a.m. and dropping off after midnight sadness (Isaac et al. 2017). According to Djelailia et al. (2021) diet, temperature, relative humidity, and physiological conditions all affect cortisol levels differently. However, according to Jansson et al. (2006) who investigated the effect of feeding frequency on the digestion and metabolism of racehorses in training, a long feeding interval (12 h) did not alter the diurnal rhythm or the diurnal mean value of cortisol, although horses showed signs of increased cortisol levels as feeding times approached.

Internal and external stimuli that may increase cortisol include fear, hypoglycaemia, fever, trauma, pulse, and sadness (Isaac et al. 2017). In a study by Steinhardt & Thielscher (1999), young calves that were transported showed signs of stress, including an increase in body temperature, heart rate, and plasma cortisol concentration. Physical exercise may also cause an increase in plasma cortisol concentrations in cattle and during many common management and handling routines (such as transport) elevated cortisol levels could be a result of either, or both, physical exercise, and psychological stress (Apple et al. 2006). Treadmill exercise (TME) was examined by Apple et al. (2006) for its impact on blood metabolites and dark-cut meat in young cattle. One of five TME treatments—4 or 8 km/h for 10 or 15 min, or a non-exercised control—was given to 25 Holstein steer calves. Blood samples were taken before, during, and after TME, and plasma glucose and serum cortisol levels were assessed. The researchers discovered that for the first six minutes of TME, serum cortisol levels were unaffected by TME; however, after that point, cortisol levels increased in steers that exercised at 8 km/h compared to steers that exercised at 4 km/h or controls. Steers that exercised at 8 km/h also experienced a sharp increase in plasma lactate levels that persisted throughout TME.

The degree of stress and the welfare of animals depends on how they interpret their surroundings. The animal's expectations of a stimulus' results are influenced by prior experiences, which influences how the animal will personally evaluate a stimulus and whether it will be seen as positive or negative (Lee et al. 2018). An animal's capacity to learn to anticipate a stimulus reaction is related to individual stress. Further, the predictability and controllability of an environment affect how animals learn, which in turn influences the welfare outcomes of the environment (Lee et al. 2018). Faecal glucocorticoids may be a very helpful biometric test because sample collection is non-invasive to subjects and as a result, does not introduce additional variables that can affect assay results. Faecal hormone metabolites are part of a larger pool of metabolites rather than reflecting the brief fluctuations that hormones in the blood undergo (Bronson 1989; Creel et al. 1996). FCM accumulation depends on several variables, including the species, nutrition, gut transit time, circadian rhythm, and individual variance of the animals, hence the relationship between faecal cortisol and plasma cortisol is not clear-cut (Stevenson et al. 2018).

The amounts of free, physiologically active glucocorticoids in the plasma are reflected in faecal glucocorticoid metabolites and the variations in the amounts of faecal glucocorticoid metabolites among the animals can accurately represent their physiological state, and consequently, their capacity to react to a stressor (Sheriff et al. 2010). The nature and length of the stressor may affect the intensity and direction of this correlation (Stevenson et al. 2018). For instance, some studies have demonstrated that whereas chronic stressors raise both plasma cortisol and FCM (Fureix et al. 2013; Stevenson et al. 2018) acute stressors only increase plasma cortisol but not FCM in horses. Therefore, it is crucial to consider the context and characteristics of the stressor as well as the physiological and behavioural reactions of the animals to comprehend the relationship between faecal cortisol and plasma cortisol (Stevenson et al. 2018). In a study by Palme et al. (2000), they utilized 16 lactating cows, mostly Austrian brown and Fleckvieh, ranging in age from three to nine years. They were all housed in tether stalls and had undergone two previous transportations. Three groups of animals were created: a transportation group, a stationary group, and a control group. Samples were taken from the cattle's faeces immediately before loading and at each defecation throughout the next 48 hours. The concentration of cortisol metabolites in faeces returned to pre-transport levels approximately 26 to 48 (median 29.5) hours after the transport began. An animal acting as its control might lessen the impact of individual variance, as was previously addressed by Palme et al. (1999). Additionally, one must consider that all cows have been transported before, hence the novelty of a situation can show an even stronger and higher psychological stress response (Grandin 1997).

4.2 Cortisol in relation to electric stimuli

Despite the common usage of electric fencing and research into virtual EFs for cattle, little is known about how electrical stimuli affect animal behaviour and stress levels. The use of electric pulses on animals raises questions about their well-being (Lee et al. 2008). In theory, electric pulses could be detrimental to an individual's health, particularly if they are not used in a way that considers animal behaviour as that would impede the animal from learning. There are also additional concerns that VF collars may result in ulcers, the equipment may malfunction, or the devices may be misused (Black-Rubio et al. 2007). According to Bristow & Holmes (2007) increased FCM concentrations can be physiological indicators of anxiety in cattle. The first long-term evaluation of the effects of virtual fencing in comparison to electric fencing is a study conducted by Campbell et al. (2019). They compared the effects of virtual fencing and electric tape fencing on cattle behaviour and welfare. There were small variations in terms of paddock utilization, body weight and FCM concentrations throughout a 4-week period between the groups. They took a faecal sample approximately a week after pasture release, and the FCM concentrations for the group with electric tape fencing was 24 ng/g and the group that later had VF activated was 25 ng/g. After the first week of activation of the VF, the group with electrical fence had a slight decrease of FCM levels at 22 ng/g and the group with virtual fencing had a decrease to 18 ng/g, there was a significant interaction for the change in FCM concentrations over time (P=0.005). However, there was no effect of fence type (P=0.09). During the five-week study period, the FMC concentrations decreased (P=0.0001), with the peak concentrations during the acclimatization period. Furthermore, all individuals in the virtual fencing group displayed a decrease in the number of electric pulses with time. However, the individual diversity in how quickly each animal learned to respond to the audio cue and how frequently they interacted with the fence was diverse, as in earlier research with beef and dairy cattle using the same system (Campbell et al. 2017; Campbell et al. 2018; Campbell et al. 2019). No individual was found to be incapable of learning within these groups, which is a sign that the animals can control and predict the stimuli. Lee et al. (2008) investigated the effects of low unexpected electric pulses (3 times with 2-second intervals) on plasma cortisol, β-endorphin, heart rate and behaviour in cattle and found that low energy electric pulses did not significantly affect their levels of cortisol or β-endorphin, but they caused an increase in heart rate and behavioural changes. Furthermore, steers restrained in a head bail or given moderate unexpected electric pulses (600 V, 250 mW) displayed the same short-term stress responses to both treatments (as measured by plasma cortisol, β-endorphin concentrations, heart rate, and behaviours).

Response from the electrical stimulus of an EF and that of a handling event such as being held in a chute for weighing (Lee et al. 2008), or the use of an electric goad and head restraint had a relatively similar cortisol response in cattle (Goonewardene et al. 2000). To evaluate the long-term consequences of low-intensity electric pulse on cattle, the authors contend that additional studies are required. According to Markus et al. (1998), if cattle can quickly recognize the indications that can be utilized to anticipate the onset of pulse, conventional electric fencing and virtual fencing that use an adequate amount of electrical stimulus should produce equivalent stress reactions.

5. Aim

The study aims are to compare cattle responses to pasture release with and without an electrical VF system. This was done by examining the animals' behaviour, activity, and faecal cortisol concentrations during weekdays 1-12. A second aim is to investigate farmers' assessments related to keeping animals at pastures and their perception of physical electrical and virtual electrical fencing.

5.1 Research questions

- Is there a difference in faecal cortisol levels between cattle that are released in a semi-natural pasture using physical EF compared to a combination of physical and VF?
- Is there a difference in activity levels between cattle that are released in a semi-natural pasture with EF compared to VF?
- How many electric pulses occur within the first week of activation of a VF?
- What is Swedish farmers' perception of the use and safety of EFs for humans and cattle?
- What is Swedish farmers' perception towards VFT?

6. Material and method

Ethical statement

All animal procedures were conducted following the Swedish Board of Agriculture’s regulations and general recommendations [SJVFS 2019:9] on research animals (Case No L150) and the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes and were conducted with institutional ethical approval obtained before the start of the experiment (RISE, dnr 5.8.18-05476-2022).

6.1 Literature

All literature was obtained by search engines Google Scholar, PubMed, ResearchGate and Springer Link.

6.2 Animals and pasture

Animals

Subjects in the VF group consisted of seven heifers, of which three were Swedish Friesian and four were a cross between Holstein/Hereford. Subjects in the EF group consisted of seven heifers, of which two were purebred Swedish Friesian, three were a cross between Swedish Friesian/Hereford, one Swedish Red-and-White x Danish Red/Hereford and one Brown Swiss Cattle/Hereford. All heifers were around 12 months of age during the test period and came from the same farm. Before selecting which of the farmer’s animals to take into the study a personality test was conducted to measure behaviour reaction to a novel object. Based on this, animals were categorised as bold or shy (the results of this test are not part of this study). The VF (n=7) and EF group (n=7) were then formed with a relativity equal number of bold individuals. The VF group had 4 bold and 3 shy heifers, the EF group had 4 shy and 3 bold heifers. All animals were fitted with a VF collar in a stable for approximately one week before being released into pasture. All individuals were naïve to EF and VF before pasture release. For the EF group, the collars were only used to locate the GPS position of each animal in relation to the electrical fence. The heifers' initial weight was between 306 and 393 kg and the collars were about 3.3-4.2% of the total body mass. This is below the advised threshold of 3-5% of an animal's body mass (Soulsbury et al. 2020).

Experimental design

For this project the experimental design was a comparison for heifers released in pasture with i) EF or ii) EF where a VF border was added within the enclosure. The collected data in this project were based on the aim to evaluate VFT with a beef producer on high-nature-value pastures during the grazing season in 2022. Parameters for stress levels were conducted through faecal collection to measure cortisol levels, as well as activity data from Nofence virtual fence collars. Two treatments were compared for 12 days using seven heifers per treatment. The treatments were a) transport and pasture release with physical EF day 1-12 (EF, Figure 1) and b) transport and pasture release with physical EF from day 1-5 and a single, straight line VF border within the physical fence during days 6-12 (VF, Figure 2). The project was conducted by a farmer in the northern part of Uppland, Sweden.

Pasture

The pastures for both groups (VF and EF) consisted of production grassland, older grassland and natural pasture with shrubs and mixed forest. Both pastures had a surrounding electrical fence with two wires and had a total area of 5.5 ha. Two measurements of voltage were conducted, one on the 19th of May 2022, when the EF pasture (Figure 1) had 6.4 kV and the VF pasture (Figure 2) had 7.2 kV. The measurement was done on one site at the fence. Additionally, a second measurement was done on the 31st of May where both pastures had a voltage between 6-6.5 kV. The measurements were done with a digital voltmeter (Kerbl no. 203892, Buchbach, Germany).

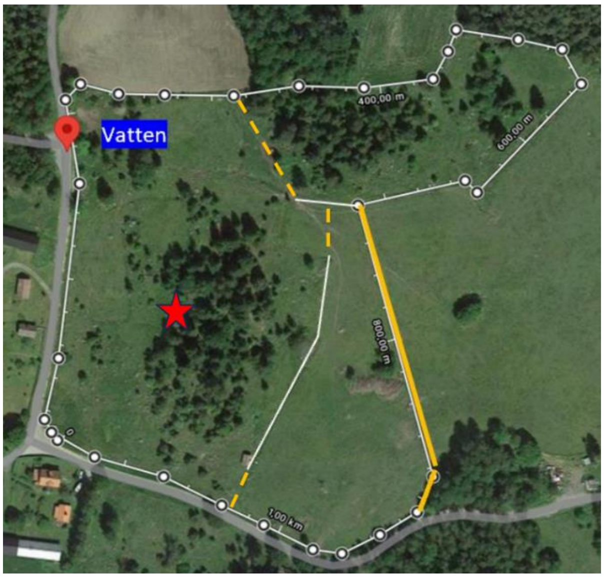

Figure 1. Photo of the pasture with physical EF only. The star shows which pasture the animals were in. White line = Preexisting electrical fence. Yellow lines= Temporary electrical fence. Blue highlighted text "Vatten" = Water resource. Red star= Shows the pasture the animals were in.

Figure 2. Photo of the pasture with physical EF (white line) and a virtual EF (red dotted line) created with the Nofence system (Nofence, Norway). Blue highlighted text "Vatten" = Water resource. The animals were in the pasture with access to water.

The animals were released into the pasture on the 19th of May 2022. During the first five days, they were acclimatised to the new environment and on the 24th of May the VF was activated in VF and the pasture area was limited to approximately

3 ha. The pasture with EF had access to the whole pasture with an area of 5.5 ha during the first five days, then also limited to 3 ha.

6.3 Virtual fence technology

The collars that were used were of the brand Nofence® (Nofence, AS, Batnfjordsøra, Norway), cattle model 2020. They were bought and owned by the Research Institutes of Sweden, RISE. The collars consisted of; a motion sensor, Bluetooth, solar-powered rechargeable battery, and GPS receiver that uses satellite signals to determine position and uses 2G and 4G networks to communicate with the Nofence app. The total weight of the collar including the neck strap, collar unit and battery was 1300 grams and had a battery capacity of 20 Ah. The animal's GPS position was triangulated through the Global Navigation Satellite Systems every 5 to 15 minutes. Additionally, a motion sensor that produced high-resolution triaxial accelerometer data (10 Hz) was able to capture movement activity. The activity data was collected through the collar's accelerometer. Collection of data such as sound signals and electric pulses occurred every 15 minutes or more often if the animal was near a VF. The information was sent to the user in the Nofence app and website.

In the Nofence app, one draws the desired grazing area on a map. If the animal moves outside the permitted grazing area a sound signal is distributed through the collar. If the animal turns back, the sound signal stops, but if the animal continues forward and the sound signal has lasted for 20 seconds, the collar will emit a weak pulse that is supposed to be unpleasant to the animal but not hurt it. The system is switched off if the animal has received three pulses without turning around. If the animal goes back into the virtual pasture of its own accord no pulse is triggered and the system automatically switches on again. There are two settings in the system, learning mode and operating mode. In learning mode, the animals only need to turn their heads for the sound to turn off, which allows the animals to learn the system more quickly. "Normal mode" is automatically activated after the animals have 20 correct reactions to the audio signal. In operate mode the animals have to turn back approximately 2 meters into the virtual pasture to turn off the sound.

An electrical fence normally has an energy output of 5 joules, 7 kV (Wahlund 2021). The pulse from a VF collar is weaker than a regular EF, about 80-90% weaker according to Nofence, that is if you assume that the maximal allowed power of 5 joule is applied in the fence. An electric pulse from the collar has a power of 0.1 joules for small ruminants and 0.2 joules for cattle with 0.2 J, 3 kV, 1.0 s. If the animal continues to advance outside the permitted grazing area after receiving the first electric pulse, a new acoustic signal will be played. The same procedure is repeated, if the animal does not turn back, another weak electric pulse is delivered. This is repeated a maximum of three times. That is, the animal can receive a maximum of three pulses at one time after which the system shuts down and the animal owner receives a notification in his app that the animal has escaped.

6.4 Faecal sample

Collection method

Faecal samples were collected six times (Table 1) from all individuals in VF (sample 1-3 (n=7), sample 4-6 (n=5)) and EF (n=7) to examine the cortisol level (Table 1).

Table 1. Time points of the faecal sample collection in all animals in two groups of heifers at pasture with physical electrical fence (EF) and virtual EF (VF).

Sample	Date	Moment
1	29.04.2022	Stable
2	20.05.2022	Day after release to pasture
3	23.05.2022	Three days after pasture release
4	25.05.2022	Day after activation of VF
5	27.05.2022	Two days after activation of VF
6	30.05.2022	Five days after activation of VF

Faecal samples were collected immediately after defecation at the same time during the day between 10.00 a.m. and 2.00 p.m., with a few exceptions where the sample was collected before 5 p.m. The time of day depended on the treatment beforehand, as the samples were collected approximately 24 hours after a new event such as release to pasture and activation of VF. Only the top portion of the sample was collected to minimize contamination. For each sample, the following data were registered: date, time of collection and individual number. Samples were collected in a clean plastic bag to avoid manual contact and were placed in a box with ice packs. These samples were within 5 hours transferred and subsequently stored in a freezer at -18°C for approximately 8 months until analysed.

A table has been created to demonstrate how the reader can better understand how the activity levels for each day relate to the cortisol samples (Table 2).

Table 2. Showing the relationship between activity data and corresponding cortisol samples for both groups.

Activity (day)	**Cortisol (Sample)**
1	4
2	-
3	5
4	-
5	6
6	-
7	-

Sample analyse method

Samples were analysed at the Department of Clinical Science at the Swedish University of Agricultural Sciences, Uppsala.

Once the faecal samples arrived at the laboratory about 10-15 g of thawed faecal matter were weighed in Petri dishes, individual weight was noted and then froze again down to -80°C and freeze-dried over the weekend. After approximately 48 h the pieces were finely divided using a mortar and 50 mg of dried extracted were placed in Precellys tubes. Methanol (1.2 ml) was added, and the tests were homogenised two times (2 x 6000 rpm x 30 s) and then incubated on a tilting table in a fume hood for about 21 h. The samples were then centrifuged (2000 x g) for 2 min and 800 µl of the supernatant was transferred to new tubes and centrifuged again (13000 x g) for 10 min. After this 600 µl was transferred to new Eppendorf tubes and placed in a fume cupboard for evaporation. When all the methanol had evaporated, 150 µl phosphate-buffered saline was added. Stainless steel mixing balls were added to the tubes and placed in a vortex mixer, when the solution was homogenised, the mixing balls were removed and placed in a rotator for 21h before the samples were put in the freezer at -80°C. The samples were thawed and then placed in a vortex mixer again and centrifuged (13000 x g x 5 min) before analysis. The prepared samples were then analysed with the Salimetrics® Cortisol Enzyme Immunoassay Kit (Salimetrics, Webster, TX, USA) according to the procedure manual. Enzyme-linked immunosorbent assay, ELISA, was conducted which is a method for identifying the presence of antigens in biological materials that uses specific antibody-antigen interactions to detect a target antigen utilising antibodies. The antigen is immobilised on a solid surface and a secondary antibody connected to an enzyme is added to detect the bound antigen after any unbound material has been removed. If the antigen is present the final product changes from a colourless substrate into colour. The medium coefficient of variance for the samples was 2.9%.

Three samples had to be run again due to inconclusive results, the medium coefficient of variance for those samples was 4.6%.

6.5 Questionary

To answer the research question about what farmers' and the industry's perception is about the use and safety of cattle grazing with EF a questionnaire was made together within a larger research project at RISE. The questionnaire asked how Swedish farmers perceive electrical fence systems from a variety of points of view, including how the system works, how user-friendly and understandable it is, how it affects work effort, the work environment and safety, how it affects the animals, what works well and what needs to be improved, external factors that they see that can affect the use of the technology, such as predators or the outdoors. This resulted in 41 questions with single-select and multiple-choice questions as well as open-ended questions. Not all questions are addressed in this study, but a selection has been made to find data that will help us achieve our objectives in this study. The questionnaire was generated by Microsoft Forms (version 2023) and sent out via three Swedish Facebook groups; "Lantbrukaren", "Vi med dikor och ungdjursuppfödning" and "Sveriges Nötköttsproducenter", together they have a following base of approximately 40 thousand. The questionnaire was open between 21.08.23 to 05.09.2023 for the groups "Lantbrukaren" and "Vi med dikor och ungdjursuppfödning", for the group "Sveriges Nötköttsproducenter" it was open between 24.08.23 to 05.09.23.

6.5.1 Selection of Questions

The selection of questions can be divided into four sections: i) demographic, ii) fence in general, and iii) EF and iv) VF. The first section consists of information about the respondents' background such as age, gender, experience working with grazing livestock and what number and types of species they currently had in 2022. For the second area, details on the types of fences they currently have enclosing their pastures, how they are managed as well as injuries related to fences on both humans and animals. The third area includes inquiries about the use of EFs and management, such as how frequently animals interact with the fence, if and why animals escape, and a technical query about the voltage of the fence. The attitudes of the respondents concerning the use of VFT are addressed in the fourth section.

6.6 Statistical analysis

All values from the cortisol faecal samples and virtual fence collars were statistically analysed using Minitab® Statistical Software (Minitab®, version 19.1.0, 2020 Minitab Inc., USA). Python (version 3.8.16) was used to sort the data from the virtual fence collars. Microsoft® Excel® for Microsoft 365 MSO (Version 2303 Build 16.0.16227.20202) were used to create figures. Figure 7 and Figure 8 were generated by Microsoft Forms. The significance level was set at $P < 0.05$ for all tests.

Cortisol faecal samples

All cortisol values were statistically analysed and subjected to a Multiple Regression Analysis with model "Cow_ID" and "Day" to investigate if they followed a normal distribution, which they did. One-way ANOVA was used to determine whether there were any statistically significant differences in cortisol content between individuals in separate groups, the model "Cow_ID", "Day" and "Group" was used. For the purpose of determining the differences between VF and EF, a one-way ANOVA was conducted, the model "Cow_ID", "Day" and "Group" was used (presented as LS means and SD).

Data from virtual fence collars

Information about the animals' activity and number of electric pulses were obtained through data collected by the VF collars each animal had on throughout the test period in the pasture. The collars register activity in two categories, "activity mid" and "activity high", and the values were summarized as one value when analysed. Python was used to create Figure 6. One-way ANOVAs were conducted in to determine any differences between total number of pulses. Excel was used to create Figure 3-5. Paired t-test was conducted to compare the activity levels between the group VF and EF.

7. Results

7.1 Number of pulses

For the first seven days with the VF activated the collars dispensed electrical pulses for the first 48 hours, for the remaining days (day 3-7) no pulses were recorded. All results are presented as mean±SD. Total number of pulses for the first day was 68 (10±3) and 18 (3±1) during day 2 (Figure 3). When comparing the number of pulses between individuals (n=7) on days 1-2, one-way ANOVA revealed no statistical significance (P=0.16).

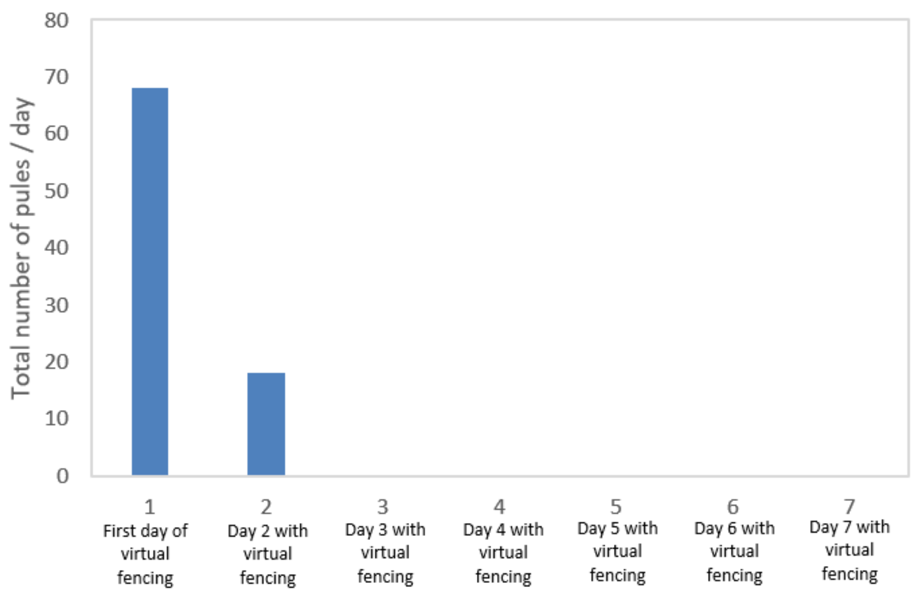

Figure 3. Daily number of pulses from a VF for all individuals the first seven days of activation of the VF, day 1-2 (n=7), day 3-7 (n=5). All individuals got >1 pulse in the first two days, but no pulses during days 3-7. Two individuals were excluded after day 2 because they had reached the max allowed number of pulses (15 pulses/individual within the first 5 days of activation in accordance with the ethical approval).

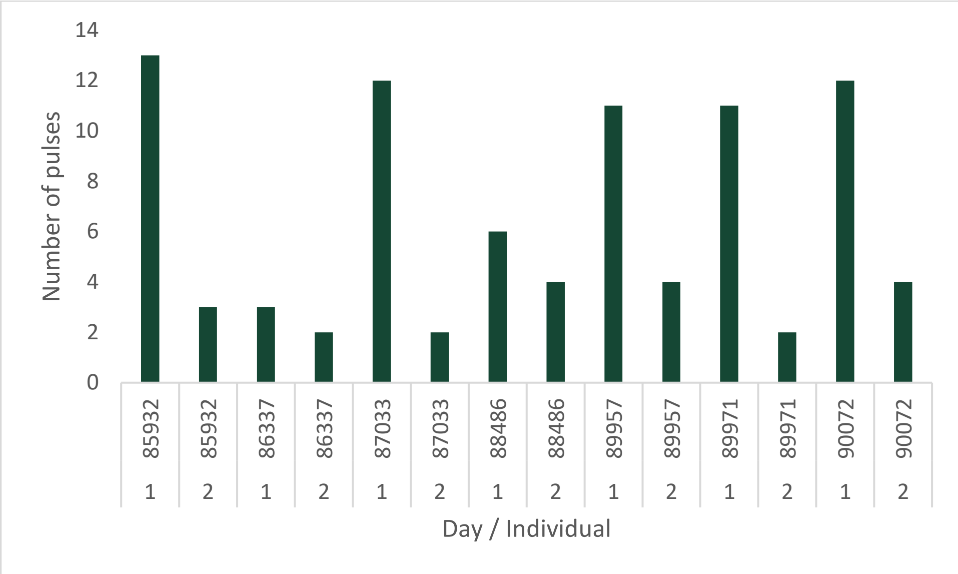

Figure 4. Number of pulses during day 1 and day 2 for each individual in the VF group (n=7).

The total number of pulses for each individual ranged between 2-8, with a total mean value of 6 pulses per individual and no significant difference in the number of pulses between individuals in the VF group (P=0.930, Figure 4). Shortly after the virtual border's activation, the entire group crossed it to reach what appeared to be one of their usual resting places, but they quickly returned to the virtual pasture and subsequently crossed it again. They then crossed the virtual border for the third time while chasing a hare. Every individual returned to the virtual pasture voluntarily and without being forced to do so when the cattle breached the virtual border. Two days after activation of the VF border two individuals were excluded due to receiving more than 15 electric pulses within 5 days, which was the limit stated in the ethical approval. One of the individuals was removed from the pasture directly, the other one remained in the pasture until 5 days later on the 30th of May, but without having any active virtual border. The delayed extraction was because the farmer did not have the opportunity to pick up the animals earlier.

7.2 Cortisol levels

In sample 1 (stable) there was no significant difference between groups and the mean value for EF was 22±5 and for the VF group it was 22±4 pg/mg (P=0.96). Sample 2 taken 24 hours after pasture release showed no significant difference (P=0.01) as EF 26±5 pg/mg and VF had 26±10 pg/mg. There was a significant difference between VF and EF during sample time 3-5 for cortisol content (Figure 5). There was no significant difference in faecal cortisol levels between individuals in the VF or EF group for sample time 1-6 (P=0.16, pooled SD=9.860).

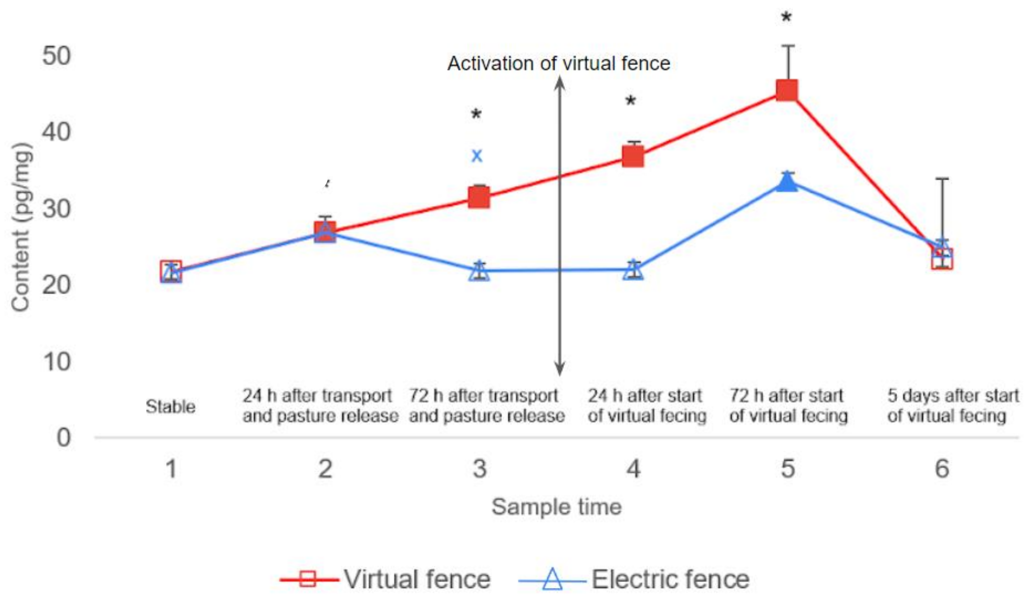

*Figure 5. Faecal cortisol levels in two groups of heifers before pasture release (1, stable) and at another five time points after pasture release presented with mean±SD. The EF group (n=6-7) was released at a pasture with a physical electrical fence only (blue) and the VF group (n=5-7) at a pasture with both a physical electrical fence and virtual electrical fence (red). The VF was activated 24 hours before time point 4. Filled marker= Significant difference (P<0.05) from sample 1. *=Significant difference between EF and VF. x= Outlier. The outlier is defined as one that exceeds the value of the SD multiplied by two.*

The VF group had significantly higher cortisol levels for sample time 2-5 compared to the stable sample (Figure 5.) Furthermore, there was no significant difference between the stable sample and sample 6 for the VF group. For the EF group, one significant difference from the stable sample could be seen in sample 5. For sample time 3, it was not possible to collect a sample from one individual in the EF group because it did not defecate (Table 3). As two individuals were excluded from the VF group, the cortisol data from them was excluded for sample time 4 and 5 (Table 3).

Table 3. Number of individuals in each group (VF and EF) for each sample time.

Sample time	VF (number of individuals)	EF (number of individuals)
1	7	7
2	7	7
3	7	6
4	5	7
5	5	7

7.3 Activity

Activity data for the first seven days after activation of the VF were used in all statistical analyses (Figure 6).

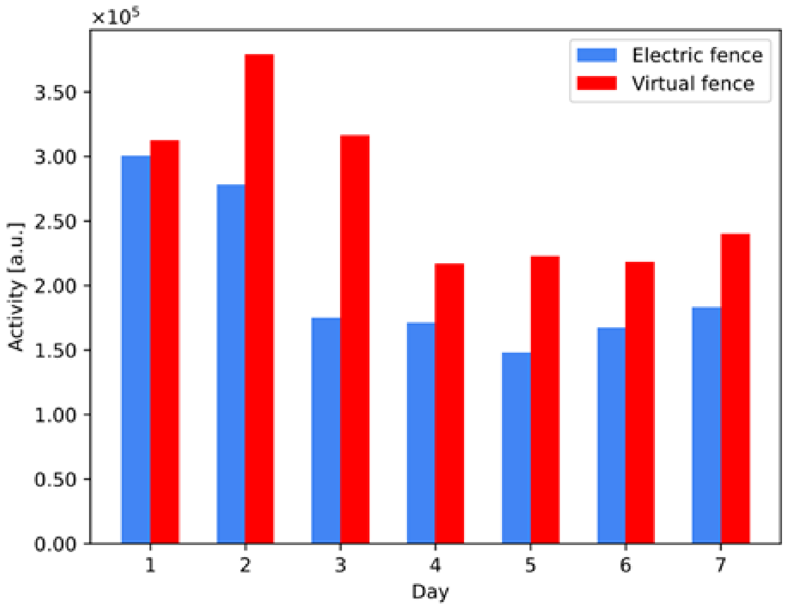

Figure 6. Total amount of activity in a group of heifers with electrical virtual fence (day 1-2 (n=7), day 3-7 (n=5) and physical electrical fence (n=7) for the seven days after activation of VF. The total mean value for VF is 1015745 [a.u] with an SD of 55563 [a.u], and the total mean value for EF is 1215273 [a.u] with an SD of 59122 [a.u]. Because error bars were tiny in comparison, they could not be seen in the picture and were therefore not displayed.

Throughout the entire period after the virtual border had been activated, the VF group exhibited a higher level of activity than the EF group (Figure 6). When comparing the VF and EF groups in total activity level over the seven days, there was no significant difference (P=0.77, Figure 6). For day 1 there was no significant difference between the groups (P=0.49, Figure 6). For day 2 (P=0.00, Figure 6) and 3 (P=0.00, Figure 6) there were significant differences between VF and EF, as well for day 4 (P=0.00, Figure 6) and day 5 (P=0.00, Figure 6). There were no significant differences on day 6 between the groups (P=0.06, Figure 6). For day 7 there was a significant difference between VF and EF (P=0.01, Figure 6).

8. Questionary

This chapter presents the responses obtained after processing the survey. Tables and charts automatically produced in Microsoft Forms have been used to present the results. The selected and analysed questions can be found in Appendix 1.

8.1 Demographics and background of the respondents

The following is a presentation of the respondents; gender, age, county in which they were active and how many years they have been farmers. The questionnaires were answered by 79 individuals for the majority of the questions, some questions they were not obligated to answer so the number of answers ranged between 70-79 individuals.

Gender, age, and experience

Of the 79 individuals 56% (n=44) identified as male, 42% (n=33) as woman and 3% (n=2) as non-binary (Table 4). The majority (60%) were between 30-50 years old (Table 4).

Table 4. Age distribution of respondents to the survey. (n=79)

Age	**Quantity**
Under 18 years	0
18-30 years	14
30-50 years	47
50-70 years	17
Over 70 years	0
Do not want to answer	1

The minority, 48%, of the respondents had been working with grazing animals for over 15 years (n=38). Secondly, 46% had experience from 6-15 years and 6% (n=5) had been working less than 5 years.

The most common animal species the respondent had grazing on the farm they either worked on or owned was cattle (87%), followed by horse (35%), sheep (33%), goat (13%) and other species (6%). The value exceeds 100% as the respondents could give multiple answers.

8.2 Types of fences

Fence usage and management

The question "What type(s) of fencing do you use for your grazing animals? (Multiple answers possible)" resulted in EF (100%), followed by barbed wire (39%), sheep net (28%), anti-predator fence (8%) and other (3%) (Figure 7), as multiple answers were possible the total value exceeds 100%. The majority (n=41) of the respondents stated that they were not satisfied with their current fences, some were neutral (n=35), and a small minority (n=3) stated that they were positive.

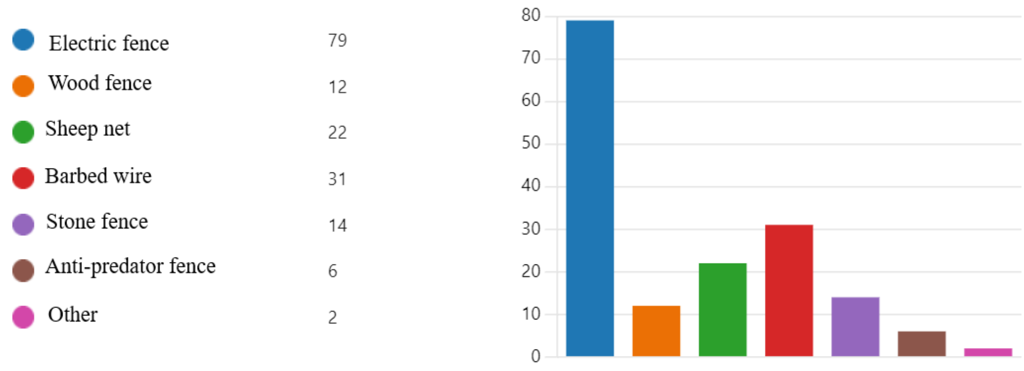

Figure 7. Chart showing what types of fences the respondents use around their grazing area(s). (n=79). Y-axis pictures number of respondents.

For the question "How much time do you estimate was spent on maintaining fencing during the 2022 grazing season? (Total, not per person)", 30% of the respondents stated that they spent 10-30 hours, 28% spent 30-50 hours and 27% spent more than 50 hours on maintenance (n=79). The majority also stated that the most labour-intensive part of keeping animals on pasture was putting up a new fence (48%), followed by maintenance of the fence (24%) (n=79).

Injuries related to electric fences

Almost half (47%) of the respondents had sometimes hurt themselves on fences (n=79). The most common commentary, with 38% of the respondents stated that it was on barbed wire or EF (n=30). They stated that they often hurt themselves being scratched by the barbed fence, others accidently touching an EF resulting in receiving an electric pulse. For the question "Have you experienced an animal being injured by a fence?", 47% said yes and 53% said no (n=79). In the commentary minor injuries like scratches were common, but also major injuries resulting in death or having to euthanise the animal consequently (n=39), most commonly from barbed wire fence. The species that were mentioned were sheep, horses, and cattle.

Electric fence

All the respondents (n=79) confirmed using electric fencing, and 52% said they maintained it by repeatedly mowing the grass and shrubs growing underneath the fence during the grazing season, 27% only did it before pasture release. Additionally, 91% (n=72) checked the voltage output multiple times as well. The question "What voltage do you think is necessary on EFs to prevent animals from escaping?" generated a wide range of answers, some did not know (n=9), additionally, the voltage from 0.8 kV to 10 kV was given as an example (total n=70). In response to the question, "How often do you estimate that animals escape from your electrically fenced pastures in a grazing season?"; 41% reported that it occurs twice to five times, 39%, once, 10%, more than five times, and 10%, never (n=79). The majority commented that it was cattle, especially calves, that escaped most often. For the question "In your opinion, what is the most common reason for animals to escape?" the most common reason was "low/no voltage in the fence" (49%), followed by the fact that they have not yet learned the fence (19%) or that they got spooked (16%), poor grazing opportunities (14%) and lastly that they got attracted by other animals nearby (3%) (Figure 8) (n=74).

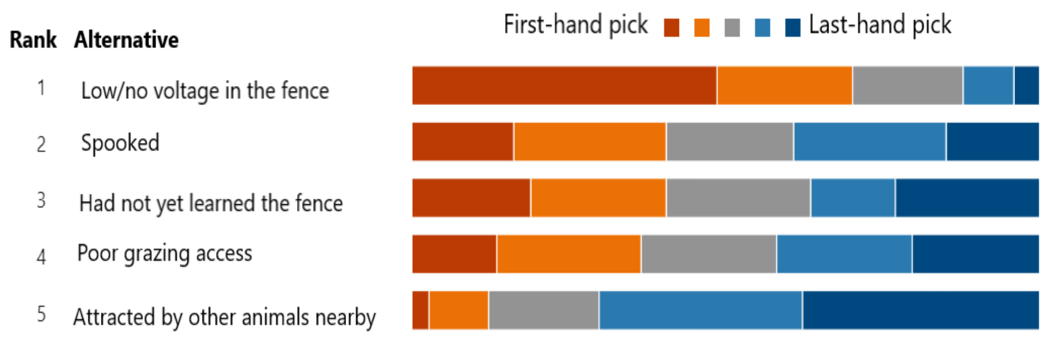

Figure 8. Showing results for the question "In your opinion, what is the most common reason for animals to escape?". (n=74). Red= First-hand pick. Orange= Second-hand pick. Grey= Third-hand pick. Light blue= Fourth-hand pick. Dark blue= Last-hand pick.

Furthermore, for the question "How common is it that you see your animals get electric pulses from the fence more than a week after grazing release?" 57% stated that they have seen the animals interact with the fence once or twice a week after pasture release, some stated that it never happens (25%), a minority had seen it happen regularly (16%) and one respondent stated they see it regularly (1%) (n=79).

Virtual fence technology

The majority of the respondents had heard about VFT (99%), and more than half (76%) said that they would use it in their production if it was allowed in Sweden (n=79). Additionally, the majority (62%) stated that it would be possible to graze larger areas if they could use VFT, some were hesitant and said maybe (23%), or said no (12%) as well as other reasons (3%) (n=77). The final question was optional, hence a lower number of response.

9. Discussion

The research aimed to compare how cattle react to pasture release with and without the use of Virtual Fencing Technology (VFT). This was achieved by monitoring the activity level and faecal cortisol levels of the cattle for the first 12 days following pasture release, using physical Electric Fencing (EF) or pasture release where a VF was activated. The second objective was to gain insight into farmers' perceptions of physical and virtual electrical fencing, as well as their opinions on VFT.

Learning and number of electric pulses

Results from this study had two individuals excluded due to receiving the maximum number of electrical pulses within 2 days. The cattle in the VF group only received electrical pulses during the first two days. The average number of pulses in total decreased steadily from day 1 (mean 10) to day 2 (mean 3), these findings are consistent with earlier studies (Markus et al. 2014; Quigley et al. 1990) that showed that cattle can be trained to react to audio signals to avoid an electric pulse within two days of training. The mean value in the study by Aaser et al. (2022) was 4 for the first 14 days, which is lower than the mean value of 7 for the first two days in this study when the cattle received electrical pulses. However, it's important to note that the methodology and experimental design used in Aaser et al.'s (2022) study were very different from those used in this study, so a direct comparison of the results is not appropriate. The cows in that study were already pregnant and gave birth to calves at the time of the study which could have influenced their results, possibly through the additional stress of giving birth as well as having to learn a new fence system. In addition, the pastures used in that study differed greatly from those used in the current study in terms of size and environment. Furthermore, the study by Aaser et al. (2022) does not disclose if they had any endpoint of the maximum number of electrical pulses that an individual could receive during the trial period. For this study, a maximum of 15 electrical pulses over five days was the end point before an individual was taken out of the pasture, so the learning period in this study was limited by the total amount of electrical pulses. Additionally, they encountered four distinct outbreaks, none of which could be attributed to unfavourable circumstances such as incorrect fence placement or drones flying too low (Aaser et al. 2022). In this study, there were the unfavourable circumstances of a hare making the VF group go over the virtual border for a third time. While no fence structure used in modern agriculture production can completely prevent escape, unexpected situations can happen, so it's important to keep this in mind when keeping animals on pasture. In terms of VFT, it's crucial to allow for a sufficient learning period as this will likely result in the cattle receiving fewer electrical pulses. Previous studies (McDonald et al. 1981; McKillop & Sibly 1988) have shown that animals that have undergone conditioning to electric fences (EFs) tend to have less contact with the fence while grazing. McDonald et al. (1981) highlighted the importance of group learning when introducing EFs, suggesting that the same approach could be taken when teaching animals to respond to VFT. Additionally, further research is needed to investigate and compare the number of pulses cattle receive from EF and VF.

Cortisol and activity

Both groups had comparable baseline cortisol levels at the start of the project because there were no significant differences between the groups in the stable sample. The levels of cortisol on individual levels in either group did not show any statistically significant differences for the seven days after the VF border was activated. It should be noted that interaction with the electric fence for the EF group was not recorded, hence we do not know if a change in cortisol or activity levels for the EF group was a result of getting an electric pulse from the fence. The VF group showed a significant increase in cortisol levels after the stable sample (sample 1) and the subsequent sample (sample 2) taken after pasture release, one might infer that the transport from the stable to the pasture could have caused a cortisol response as the VF group experienced the transport stressful (Figure 5). If we are to say that transportation has an impact on cattle which is shown in the cortisol faecal matter after 24 hours, this is in accordance with Steinhardt & Thielscher’s (1999) study where they saw physiological changes that indicated stress when transporting young calves. Additionally, this response could have been brought on by activation such as running and playing in the pasture after release.

Sample 3 had a significant increase for the VF group, which gives us a significant difference for the VF group but not for the EF group. The increase could be explained by the hare or other random factors. For example, could the individuals in the VF groups have been a group with individuals that are more active. Particularly if their elevated cortisol levels occurred without the presence of a stressor, like being introduced to VF, since activity is known to elevate cortisol production (Lee et al. 2008). The study by Apple et al. (2006) presented results where steers that walked at 8 km/h compared to 4 km/h on a treadmill had higher cortisol levels. One possible reason behind the significantly higher cortisol levels during sample times 3-5 for the VF group, could be that they generally were more active and had a higher pace when walking than the EF group. On the contrary, the

EF group had cortisol levels in sample 3 that were comparable to the stable sample (sample 1). Furthermore, that level was held until sample 4. If one hypothesis is that more activity leads to higher cortisol levels that do not seem to be the case in this study. The VF group had a significant increase in cortisol levels for sample 4, which is when they received the greatest number of pulses. The increase could also be due to succumbing to the stressor of chasing the hare in the pasture right after the activation of the virtual border. Additionally, the group dynamic could have shifted after the two individuals were removed from the VF group, resulting in a higher activity level in the group.

There have been few studies on virtual fencing, making it difficult to compare cortisol levels to earlier studies. However, if we were to compare the results in Campbell et al. (2019) study where they saw FCM levels ranging from 22 to 24 ng/g for the EF group, versus 18 to 25 ng/g for the VF group, there is a high difference in cortisol levels for their EF group the first week on pasture in comparison to this study where the FCM levels in our EF were at 33 ng/g 24 hours after pasture release. The levels for their VF group compared to this study are a lot more similar where this study has a level of 25 ng/g 24 hours after pasture release. In the Hamidi et al. (2022) study they had FCM ranging from 14.3 ± 7.11 ng/g, they did not see any significant effects depending on which fence system was used. Respectively, Sonne et al. (2022) had levels ranging between 11 ng/g to 42 ng/g, with no significant differences between individuals. Once again, it's challenging to compare the values of this study with other studies due to the differences in their methodologies. Therefore, further research needs to be conducted to determine whether the cortisol levels found in this study can be applied to other cattle when exposed to VFT. As cortisol levels are influenced by various factors like diet, temperature, relative humidity, and physiological conditions, it's important to conduct more studies to investigate the effects of VFT in relation to these different variables (Djelailia et al. 2021).

One of the questions asked by Aaser et al. (2022) was if a cow's level of activity is compromised or altered following an electrical pulse. They did not find any discernible alternations such as significant differences in activity before and after an electric pulse. When comparing the total activity levels for the VF group and EF group there are statistical differences on days 2, 3, 5 and 7. That means that the results of this study are not consistent with those from Campbell et al.'s (2019) study, which found very little differences between the groups using VF and those using electrical tape fencing regarding activity levels.

9.1 Questionnaire

Although the majority of respondents had EFs enclosing their pastures, they either weren't happy with them, or they weren't sure about how they felt regarding their fences. Their dissatisfaction may have been due to the fact that installing or maintaining fencing was one of the most labour-intensive tasks involved in keeping cattle on pasture. The amount of maintenance work each year could range from 10 to 30 hours up to 50 hours in one grazing season. Maintenance can involve tasks such as mowing the grass under the wire/band or checking the voltage during the grazing season, which most respondents stated that they did multiple times. Brier et al. (2020) as well as Umstatter (2011) mentioned that labour cost savings were identified as possible benefits of using VFT. For speculation, one could argue that these time- and cost-labour tasks would drastically lower or be cut if these farmers should implement VFT instead of having EF surrounding their pastures. This could be especially beneficial to farmers who have cattle in their livestock as those were the species that were mentioned as the most common species to escape pastures. If one would conclude that an animal has learned the fence if they do not get any electrical pulses, most of the animals that the respondents kept in pastures with EFs appeared to accurately learn to avoid contact with the fence a week following pasture release as stated by the respondents. Reasons why animals escaped out of their pastures, were either because the fence's voltage was low or because the animals had not yet figured it out. This supports the claim made by McDonald et al. (1981) that cattle would attempt to cross an EF if the power is interrupted, thus it's critical to provide power to the fence continually to reduce the likelihood that animals will escape. It's not unexpected for some farmers to experience animals crossing the EF border. This is because some respondents have claimed that they are unaware of the voltage of their fence. It's probable that the voltage is too low to create discomfort for the animals.

According to the respondents' attitudes toward VFT, the majority of them would consider using it on their farms since it would enable them to graze more land. This is in accordance with Umstatter (2011) who stated that VFT could be used where it is not feasible to install a physical fence. If VFT were utilized instead of EF to regulate certain regions, it would result in more effective land use as previously discussed by Campbell et al. in 2017. Furthermore, if the respondents could have access to larger grazing areas, it opens the possibility to prolong the grazing season which in turn could be beneficial for the farmer if he could advertise that as a special meat product and contribute to biodiversity. According to Crump et al. (2019), full-time housing may have a negative impact on cattle welfare, as stated by animal welfare scientists and dairy consumers. Meanwhile, Stampa et al.'s study (2020) found that respondents expressed an intention to support pasture grazing through their purchasing decisions. This suggests that there may be a mutually beneficial arrangement for both farmers and consumers. This, while it is not yet applicable in Sweden due to the country's obligation for cattle to graze, is immensely relevant in other parts of the world that are not obligated to let cattle graze outside during a part of the year.

The studies conducted by Brier et al. (2020) and Maier & Shobayashi (2001) explored the attitudes of the public and consumers towards Virtual Fence Technology (VFT). These studies revealed that one of the main concerns related to the implementation of this technology is the lack of knowledge about its potential impact on animal welfare. To prevent the spread of misinformation about the technology, it's important to accurately explain how VFT works. Additionally, the socio-ethical implications of implementing VFT in Sweden, as previously discussed by Brier et al. (2020), need to be carefully considered. Further research is necessary to address potential ethical concerns and identify solutions for various stakeholders, including the general public, consumers, and animal owners.

9.2 Future research questions

Since the field of cattle released on pasture with EF is relatively unexplored, there is a lack of studies to compare the results of this thesis against. This is particularly intriguing given that modern agricultural practices in Sweden and all around the world use EF relatively frequently. So further studies should be conducted on the effects EF have on cattle, for the learning period as well as a whole grazing season. Additionally, I would recommend conducting a comparison between VF and EF when investigating the number of electrical pulses received per individual and group setting.

There is a maximum of 5 joules allowed according to EU regulations, but nowhere is it stated what the recommended output is, should one presume that farmers have the maximum allowed output in their fences? Firstly, one would need to know the voltage output in regular electrical fenced pastures; are there major differences in the amount of electricity coming in versus going out in a circumstance where the cattle encounter the fence? When teaching cattle how an EF operates, does the voltage have to be greater than ‘normal’, or can it be lowered once they have grasped the concept? Or, if lowered, would the cattle force it? I think it should be highly relevant to investigate the common standard practice for Swedish farmers’ fences so one could accurately compare the electric pulses given from EFs in modern Swedish agriculture.

Suggestions for future research questions:

- Could the learning time for cattle be limited if they learned the technology together with cattle that are already accustomed to virtual fencing?
- Do cows' learning capacities to VF technology depend on their personalities?
- What is the impact of conspecific behaviour when cattle learn VF technology? Could any correlation be drawn to the cattle's personality?
- How many electric pulses are received for cattle when learning EF? How many occur during a grazing season?

9.3 Methodology

Experimental study

This was the first study on cattle and VFs to be carried out in Sweden, and to the best of my knowledge, it was also the first study to examine the behaviour of cattle released in pastures with EFs. A larger number of animals could have been preferable in hindsight as two individuals were eliminated already on day 2, leaving only 5 animals in the VF on days 3–7. Further studies should be carried out with a focus on variations of individuals with different types of personalities, keeping in mind that one of the main questions the SBA would like addressed is the individual and inter-individual variations within cattle when they learn VFT, to possibly make an allowance for it to be used commercially by farmers in Sweden.

Previous research in the field of virtual fencing has not, to my knowledge, considered individuals' different personalities which could have an impact on the differences when learning new technology such as responding to an audio cue to not get an electric pulse. It may be possible for the animal owner to customize the learning period to each individual since you may choose whatever mode the collar is set to. For instance, if an animal is finding it difficult to adapt to the system, it is possible that it could spend more time than its fellow herd members in "learning mode". If more research on the relationship between personality and learning capacity for cattle reveals that some personalities favour quick learning, that information might be taken into account when introducing VFT for cattle. Lastly, bold personality qualities were shared by both eliminated individuals in the VF group. This could have had an impact on the dynamics of the groups and, in turn, the study's findings, that is not something that was a part of this thesis but an interesting point to further examine in future research.

Questionnaire

If one would like to conduct comparable research for other livestock farmers in Sweden or other nations, the questionnaire method used for this study has the advantage of being simple to duplicate. However, the methodology's reliance on survey results is a limitation. The results of the questionnaire are thus contingent on reaching a sufficient number of farmers with a sufficiently wide base of responses. Due to the survey being distributed across multiple Facebook groups, the deadline for responding varied for each group, which may have caused inaccuracies. According to Facebook's algorithm, a higher response rate could have been achieved through sponsored posts or other methods.

10. Conclusion

Experimental study

The results from this study show that the response from letting cattle on pastures with EF versus VF has some differences when investigating the faecal cortisol levels. The VF group had increased cortisol levels in four sample times, compared to the EF group which had an increase for one sample time. There was no apparent explanation for the EF group's significant difference, which was only seen in sample 5. The activity level was higher in the VF group than the EF group throughout the entire period (days 1-7) after activation of the virtual border. Compared to the EF group there were significant differences for the majority of days. There were no significant differences between individuals in the VF group regarding the number of electric pulses, the mean value for each individual was 10 for day 1, for day 2 it was 3, and zero for the rest of the study period of five days. Total number of pulses varied from 2-8 per individual without any significant differences, that is if you exclude the one that got removed due to maximum number of allowed pulses. In conclusion, the learning time for cattle in this experiment seems to be a period of two days, which also corresponds to previous literature. However, additional studies with a larger number of animals are required to determine how VFT affects the welfare of cattle.

Questionnaire

Cattle were the most common species for escaping the pasture, the most frequent reasons stated by the respondents were low/no voltage in the fence or that the animals had not yet been accustomed to the EF. This occurred within the first seven days after the pasture release. After a week had passed it was not so common for animals to escape. Swedish farmer's primary fence type was EF, they stated that they were not happy with their current fence situation. This could to some extent be related to labour-intensive work for the maintenance of EFs. That could also act as an inquiry that the majority of the respondents would like to use VFT in their practice if allowed in Sweden. Additionally, this would allow greater grazing opportunities for some farmers. The results of the study together with the answers from the questionnaire indicate that VF systems may be a useful alternative to conventional fencing for managing cattle grazing in semi-natural pastures. Because they are more flexible and timesaving, VF systems may change the way cattle are managed and can result in more profitable and sustainable livestock production.

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Populärvetenskaplig sammanfattning

Virtuella elstängsel (VE) är ett hett ämne i dagens lantbrukssektor. Flera länder så som Norge, Spanien och Australien har legaliserat tekniken, men Sverige har ännu inte gjort det. Jordbruksverket som ansvarar för att besluta om en eventuell lagändring för att tillåta virtuell elstängselteknik (VET) i Sverige för kommersiellt bruk, har begärt att fler vetenskapliga studier måste genomföras i Sverige innan de kan ta ett beslut om eventuell ändring i lagstiftningen. Detta för att Jordbruksverket anser att de behöver mer information om hur VET påverkar djurens välfärd.

Projektets huvudsyfte var att jämföra nötkreaturs reaktion när de släpps i ett naturbetesområde med elstängsel i jämförelse med en hage med en virtuell gräns. Studien genomfördes av SLU och RISE under sommaren 2022 i samarbete med en nötköttsproducent belägen i Uppland, Sverige. Under 12 dagar jämfördes effekterna av två behandlingar med sju kvigor i varje grupp. Behandlingarna var som följande: (grupp VE) transport och betessläpp med fysiskt elstängsel från dag 1–12, och (grupp E) transport och betessläpp med fysiskt elstängsel från dag 1-5, och för dag 6–12 en VE-linje och tre sidor med elstängsel. Data samlades in från tre olika parametrar; i) antal stötar, ii) träckprover och iii) aktivitetsnivå. Halsband med VET från Nofence sattes på alla individerna i båda grupperna för att registrera aktivitetsnivå samt antal elstötar. Då kortisol är en väldokumenterad metod för att mäta eventuella stressreaktioner hos djur samlades träckprover in vid sex tillfällen för att analysera kortisolhalten innan och under behandling. Dessa parametrar valdes för att bedöma om det var någon skillnad i behandlingens effekt både på individ- och gruppnivå. Kortisolnivåerna ökade efter transport och betessläpp hos båda grupperna. Kortisolnivåerna i VE-gruppen var signifikant högre för provtid 2-5 i jämförelse med stall provet (prov 1) (Figur 5). Det högsta kortisolvärdet mättes hos grupp VE tre dygn efter aktivering av den virtuella linjen. Det fanns ingen signifikant skillnad mellan provtillfälle 1 (stallprov) och sista provet fem dagar efter aktivering av den virtuella linjen (prov 6) för VF-gruppen. För E-gruppen kunde en signifikant skillnad från det stall provet ses i prov 5. Ökningen av kortisolhalten hos E gruppen för prov 5 är svår att förklara, då de inte var utsatta för någon stressor i behandlingen.

VE-gruppen mottog elstötar under de två första dygnen efter aktivering av den virtuella gränsen. För dag 1 var medelantalet 10, för dag 2 var medelvärdet 3. Det fanns ingen statistisk signifikans mellan individerna i grupp VE gällande antalet pulser. För aktivitetsnivån såg man en skillnad majoriteten av dagarna när man jämförde grupper VE mot E. Under hela perioden efter att den virtuella gränsen hade aktiverats uppvisade VF-gruppen en högre aktivitetsnivå än EF-gruppen (Figur 6). Vid jämförelse av VE och E grupperna i total aktivitetsnivå under de sju dagarna fanns det ingen signifikant skillnad (P=0,77, Figur 6). För dag 2 (P=0,00, figur 6) och 3 (P=0,00, figur 6) fanns det signifikanta skillnader mellan VE och E, liksom för dag 4 (P=0,00, figur 6) och dag 5 (P=0,00, figur 6). För dag 7 fanns det en signifikant skillnad mellan VE och E (P=0,01, figur 6).

Andra målet i denna studie var att samla in information om svenska lantbrukares inställning och uppfattning om elstängsel och virtuella stängsel vid hantering av betande boskap. Detta gjordes genom att skicka ut en enkät i olika Facebookgrupper. Resultatet visade att majoriteten av de svarade hade elstängsel som huvudsakligt stängsel runt sina betesområden, resultaten visar att majoriteten inte är nöjda med det. Vidare så var de flesta respondenter positivt inställda att implementera VET i sin verksamhet, då detta skulle göra det möjligt för dem att använda större områden än vad de för närvarande kan som betesmarker för sina djur.

Sammanfattningsvis fanns det vissa skillnader i reaktioner hos grupperna men vidare studier behöver genomföras för att kunna dra slutsatser på vad det beror på.

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Appendix 1: Questionnaire

1. Kön
    - a. Man
    - b. Kvinna
    - c. Icke binär
    - d. Vill inte uppge

2. Ålder
    - a. Under 18 år
    - b. 18–30 år
    - c. 30–50 år
    - d. 50–70 år
    - e. Över 70 år
    - f. Vill inte uppge

3. Hur lång arbetslivserfarenhet har du av betesdjur?
    - a. 0–5 år
    - b. 6–15 år
    - c. Över 15 år

4. Vilka betande djurslag och antal har du på din gård (år 2022)?
    - a. Nöt
        - i. Antal:
    - b. Får
        - i. Antal:
    - c. Get
        - i. Antal:
    - d. Annat
        - i. Antal:

5. Vilket typ av stängsel använder du huvudsakligen?

a. Elstängsel
b. Trästaket
c. Nät
d. Taggtråd
e. Stengärde
f. Rovdjursstängsel
g. Annat

6. Hur nöjd är du med dina val av stängsel?
1 (väldigt missnöjd) –10 (väldigt nöjd)

7. Hur mycket tid uppskattar du åtgick till att sätta upp nya stängsel under betessäsongen 2022?

a. 0–10 timmar
b. 10–39 timmar
c. 30–50 timmar
d. Mer än 50 timmar

8. Vilket moment är mest arbetskrävande med att hålla djur på bete? Klassa från störst till minst (1–6)

1. Sätta upp nytt stängsel
2. Underhålla stängsel
3. Tillsyn av djur
4. Hantering av djur (transport till och från bete)
5. Hantering av djur (flytt mellan beten)
6. Annat:

9. Har du någon gång skadat dig på stängsel?

a. Ja
b. Nej

10. Har du varit med om att ett djur fått skador av stängsel?

a. Ja
b. Nej

11. Använder du dig av elstängsel?

a. Ja
b. Nej

12. Hur ofta brukar du röja under elstängslet?

a. Aldrig
b. Endast innan betessläpp
c. Några gånger under betessäsongen

13. Brukar du kolla spänningen i eltråden?

a. Nej
b. Ja, vid betessläpp
c. Ja, några gånger under betessäsongen
d. Jag har digital övervakning av spänning i eltråden

14. Vilken spänning anser du krävs på elstängslet för att djuren inte ska rymma?
Fritext svar

15. Hur vanligt är det att djur rymmer ur era hagar med elstängsel?

a. Aldrig
b. 1–2 ggr/betessäsong
c. 2–5 ggr/betessäsong
d. 5–10 ggr/betessäsong
e. >10 ggr/betessäsong

16. Vilken är den vanligaste orsaken till att djur rymmer, enligt din uppfattning? Ranka alternativen nedan med störst sannolikhet högst upp.

1. Låg/ingen spänning i tråden
2. Skrämda
3. Hade inte lärt sig staketet ännu
4. Dåligt med betestillgång
5. Lockas av andra djur i närheten

17. Hur vanligt är det att du ser dina djur få stötar av stängslet mer än en vecka efter betessläpp?

a. Det händer aldrig
b. Jag har sett det någon enstaka gång
c. Det förekommer
d. Jag ser det ganska ofta

18. Har du hört talas om den nya tekniken virtuella stängsel?

a. Ja
b. Nej

19. Om det var tillåtet att använda virtuella stängsel i Sverige, skulle du då vara intresserad av att använda det i din drift?

a. Ja
b. Nej

20. Skulle du beta större arealer än du gör idag om du kunnat använda virtuella stängsel?

a. Ja
b. Nej
c. Kanske
d. Annat

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