CSIRO

Australia's National
Science Agency

Inquiry into Prevention of Cruelty to Animals Amendment (Virtual Stock Fencing) Bill 2024

Committee on Investment, Industry and Regional Development

CSIRO Supplementary questions

July 2024

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[redacted]

Responses to supplementary questions

1. **Can CSIRO provide more details of its 'learning principles' and 'welfare assessment' frameworks for virtual stock fencing (uncorrected transcript, page 41)? What are the animal welfare benefits of these frameworks?**

Learning principles

Any virtual fencing system will have an algorithm incorporated into it that contains the code for when cues will be applied to the animals. To avoid adverse animal welfare outcomes, it is critical that any algorithm developed be aligned with animal learning theory and best practice animal training principles. The application of cues should ensure that their timing and consistency facilitate clear learning, for example, the benign cue (audio or vibration) should be closely paired with the aversive stimulus (electric shock) so that the animals can quickly learn the association between them, and avoid the electric shock by turning or stopping in response to the warning audio/vibration cue alone, thereby avoiding receiving an aversive electric shock.

Welfare assessment frameworks

To be ethically acceptable, new husbandry technologies and livestock management systems must maintain or improve animal welfare. To achieve this goal, the design and implementation of new technologies need to harness and complement the learning abilities of animals. CSIRO developed a framework to assess welfare outcomes in terms of the animal's affective state and its learned ability to predict and control engagement with the environment, including, for example, new technologies. In cognitive activation theory of stress (CATS), animals' perception of their situation occurs through cognitive evaluation of predictability and controllability that influence learning and stress responses. Stress responses result when animals are not able to predict or control both positive and negative events. Successful learning occurs when the animal perceives cues to be predictable (audio warning always precedes a shock) and controllable (operant response to the audio cue prevents receiving the shock) and an acceptable welfare outcome ensues. However, if animals are unable to learn the association between the audio and shock cues, the situation retains low predictability and controllability, leading to states of helplessness or hopelessness, with serious implications for animal welfare. New technologies or systems should ensure that predictability and controllability are not at low levels and that operant tasks align with learning abilities to provide optimal animal welfare outcomes.

An overview of the **welfare assessment framework** and learning principles for virtual fencing are contained in: Lee, C., Colditz, IG, and Campbell, DLM (2018). A framework to assess the impact of new animal management technologies on welfare: a case study of virtual fencing. Frontiers in Veterinary Science, https://www.frontiersin.org/articles/10.3389/fvets.2018.00187/full.

An overview of the animal **welfare assessment measures** and approaches are outlined in the following paper: Lee C and Campbell DLM (2021) A Multi-Disciplinary Approach to Assess the Welfare Impacts of a New Virtual Fencing Technology. Front. Vet. Sci. 8:637709. doi: 10.3389/fvets.2021.637709

Abstract: Virtual fencing involving the application of audio cues and electrical stimuli is being commercially developed for cattle. Virtual fencing has the potential to improve productivity through optimized pasture management and utilization by grazing animals. The application of virtual fencing initiates public concern for the potential welfare impacts on animals due to the aversive nature of using an electrical stimulus. It is therefore important to provide welfare assurance of the impacts of virtual fencing on livestock. In this paper, we provide an overview of the welfare assessment and validation stages for virtual fencing which could be applied to other new technologies utilizing novel systems. An understanding of stress measures and their suitability for use in specific contexts is discussed, including the use of glucocorticoids to measure both acute and chronic stress, and behavioral responses and patterns to indicate welfare states. The importance of individual differences in relation to learning and cognition are also highlighted. Together, this *multi-disciplinary approach to welfare assessment provides a tool kit that may be applied for welfare assurance of some new technologies and systems for farm animals.*

Animal welfare benefits

High predictability and controllability and successful learning are important in affecting optimal animal welfare as demonstrated in the diagram below (From Lee et al., 2018).

Figure 1

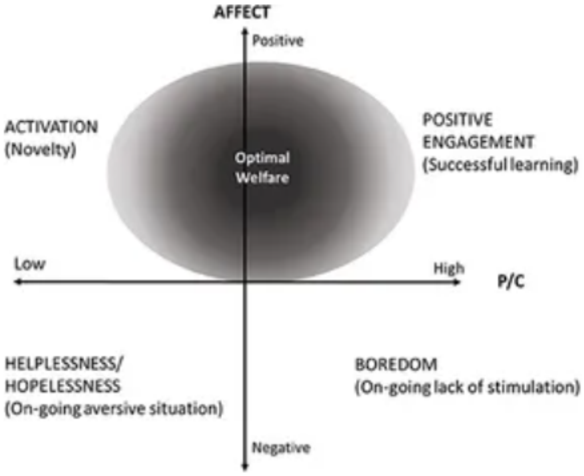

Figure 1. Proposed framework showing the interaction between predictability/controllability (P/C), affect and welfare states. Shaded area indicates intermediate P/C where optimal animal welfare occurs.

2. **At the hearing, you noted a list of references of publications by CSIRO on virtual stock fencing (uncorrected transcript, page 41). Can you provide this list of references to the Committee?**

CSIRO Publications on Virtual Fencing

Lee, C., Colditz, IG, and Campbell, DLM (2018). A framework to assess the impact of new animal management technologies on welfare: a case study of virtual fencing. Frontiers in Veterinary Science, https://www.frontiersin.org/articles/10.3389/fvets.2018.00187/full.

Lee C and Campbell DLM (2021) A Multi-Disciplinary Approach to Assess the Welfare Impacts of a New Virtual Fencing Technology. Front. Vet. Sci. 8:637709. doi: 10.3389/fvets.2021.637709

Campbell DLM, Lea JM, Keshavarzi H and Lee C. 2019. Virtual Fencing is comparable to Electric Tape Fencing for Cattle Behavior and Welfare. Front. Vet. Sci. 6:445. doi: 10.3389/fvets.2019.00445

Dana L.M. Campbell, Jim M. Lea, William J. Farrer, Sally J. Haynes and Caroline Lee. 2017. Tech-savvy beef cattle? How heifers respond to moving virtual fence lines. Animals, 7, 72; doi: 10.3390/ani7090072.

D. L. M. Campbell, D. Marini, J. M. Lea, H. Keshavarzi, T. R. Dyall and C. Lee. 2021. The application of virtual fencing technology effectively herds cattle and sheep. Animal Production Science, https://doi.org/10.1071/AN20525

Caroline Lee, John M. Henshall, Tim J. Wark, Chris C. Crossman, Matt T. Reed, Heather G. Brewer, Julian O'Grady and Andrew D. Fisher. (2009). Associative learning by cattle to enable effective and ethical virtual fences. Applied Animal Behaviour Science, 119:15- 22.

Lee C, Fisher AD, Reed MT, Henshall JM. (2008) The effect of low energy electric shock on cortisol, beta-endorphin, heart rate and behaviour of cattle. Applied Animal Behaviour Science, 113:32-42.

D. L.M. Campbell, D. Marini, J. M. Lea, H. Keshavarzi, T. R. Dyall, and C. Lee. 2021. The application of virtual fencing technology effectively herds cattle and sheep. Animal Production Science. https://doi.org/10.1071/AN20525

Campbell, D.L.M.; Belson, S.; Lea, J.M.; Ouzman, J.; Lee, C.; Kalinowski, T.; Mowat, D.; Llewellyn, R.S. Automated Virtual Fencing Can Effectively Contain Sheep: Field Trials and Prospects. Animals 2023, 13, 619. https://doi.org/10.3390/ani13040619

Marini Danila, Cowley Fran, Belson Sue, Lee Caroline (2022) Comparison of virtually fencing and electrically fencing sheep for pasture management. Animal Production Science, https://doi.org/10.1071/AN21459.

Kearton T. Marini D, Lee C, Cowley F (2022). The influence of observing a maternal demonstrator on the ability of lambs to learn a virtual fence. Animal Production Science. doi:10.1071/AN21180

Dana L.M. Campbell, Jackie Ouzman, Damian Mowat, Jim M. Lea, Caroline Lee and Rick Llewellyn. 2020. Virtual fencing technology excludes beef cattle from an environmentally sensitive area. Animals 2020, 10, 1069; doi:10.3390/ani10061069.

Hamideh Keshavarzi, Caroline Lee, Jim M. Lea, and Dana L.M. Campbell. 2020. Virtual fence learning is socially facilitated in beef cattle. Frontiers in Veterinary Science, 10.3389/fvets.2020.543158.

Tellisa Kearton, Danila Marini, Frances Cowley, Hamideh Keshavarzi, Sue Belson, Bonnie Mayes and Caroline Lee. The influence of predictability and controllability on stress responses to the aversive component of a virtual fence. Frontiers in Veterinary Science. 77: 580523. doi:10.3389/fvets.2020.580523.

Marini D, Kearton T, Ouzman J, Llewellyn R, Belson S, Lee C. 2020. Social influence on the effectiveness of virtual fencing in sheep. PeerJ 8:e10066 https://doi.org/10.7717/peerj.10066

Megan Verdon, Caroline Lee, Danila Marini, Richard Rawnsley. 2020. Pre-exposure to an electrical stimulus primes associative pairing of audio and electrical stimuli for dairy heifers in a feed attractant trial. Animals, 10, 217; doi:10.3390/ani10020217

Danila Marini, Fran Cowley, Sue Belson, Caroline Lee. 2019. The importance of an audio cue warning in training sheep to a virtual fence and differences in learning when tested individually or in small groups. Applied Animal Behaviour Science, 221, 104862. https://doi.org/10.1016/j.applanim.2019.104862.

Dana L.M. Campbell, Sally J. Haynes, Jim M. Lea, William J. Farrer and Caroline Lee. 2019. Temporary exclusion of cattle from a riparian zone using virtual fencing technology. Animals. (1), 5; https://doi.org/10.3390/ani9010005.

Tellisa Kearton, Danila Marini, Frances Cowley, Susan Belson, Caroline Lee. 2019. The effect of virtual fencing stimuli on stress responses and behaviour in sheep. Animals, 9(1), 30; https://doi.org/10.3390/ani9010030.

Danila Marini, Rick Llewellyn, Sue Belson, Caroline Lee. 2018. Controlling within-field sheep movement using virtual fencing. Animals, 8, 31; doi:10.3390/ani8030031

Danila Marini, Dennis M Meuleman, Sue Belson, Bas T Rodenburg, Rick Llewellyn and Caroline Lee. 2018. Developing an ethically acceptable virtual fencing system for sheep. Animals, 8, 33; doi:10.3390/ani8030033.

Dana L.M. Campbell, Jim M. Lea, Sally J. Haynes, William J. Farrer, Chris Leigh-Lancaster and Caroline Lee. 2017. Virtual fencing of cattle using an automated collar in a feed attractant trial. Applied Animal Behaviour Science, 200: 71-77. https://doi.org/10.1016/j.applanim.2017.12.002

Lee C, Prayaga KC, Fisher AD, Henshall JM. (2008) Behavioral aspects of Electronic Bull separation and mate allocation in multiple sire mating paddocks. Journal of Animal Science, 86: 1690-1696.

3. A recent United Kingdom government report identified potential risks of different dynamic grazing and herding methods, such as back fencing or virtual herding.[1] In your experience, are there methods of moving or fencing animals with virtual fencing that pose risks to animal welfare? What regulations or guidance could be put in place to mitigate these risks?

CSIRO is unable to comment on regulations and guidance. However, the above-mentioned papers, specifically, Campbell et al., 2021 (D. L. M. Campbell, The application of virtual fencing technology effectively herds cattle and sheep. Animal Production Science, https://doi.org/10.1071/AN20525) could be a helpful resource.

4. How do the age and experience of stock animals affect their ability to adapt to virtual fencing technology?

CSIRO is unaware of any studies comparing different age classes for their ability to adapt to VF technology. Overall, we do see quite a lot of variation between animals in their behavioural responses, willingness to test the virtual fence and ability to learn to respond to the audio cue to avoid the electric shock.

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