Wearable technology for deer

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Background

The benefits of wearable technology in the livestock sector have been promoted and recognised as a potentially transformative technology through the potential labour and cost savings associated with monitoring livestock health and welfare (Barwick *et al.* 2020). Livestock wearing technological devices is a relatively common sight on many dairy farms around New Zealand. These devices come in all shapes and sizes including neck collars, ear tags, and internal sensors and are used for a multitude of purposes including monitoring animal health, detection of oestrus and controlling where and when animals can graze (virtual fencing). However, the use of wearable technology in the dry stock farming sector is not as prominent (Fogarty *et al.* 2017) for logistical and cost reasons. They are nevertheless beneficial in the dry stock sector as they have the potential to improve welfare outcomes through early detection of animal health issues, or other animal distress and provide the opportunity to maintain our social license to farm through the demonstration of positive animal welfare metrics. There is also the opportunity to increase profitability by improving animal and feed resource utilisation efficiency and protect environmentally sensitive areas through phenotyping and genetic selection, or controlled grazing. Additional benefits around behavioural phenotyping that can be used for management and genetic selection purposes include prediction of parturition date (Asher *et al.* 2002).

Wearable technologies offer advantages over traditional methods of capturing animal behaviour and welfare as they can capture objective continuous data from animals remotely and in real time (Neethirajan 2024), reducing the chances of disturbances and the use of artificial restricted environments that allow for easy viewing opportunities. For behavioural data interpretation to be accurate and effective, wearable technology needs to be carefully validated for the specific requirements and species intended for use.

The objectives of this research were to develop a low-cost wearable device that was validated to measure a range of behaviours in red deer. The target end users for this product were primarily researchers, but there was consideration that the knowledge generated would have wider livestock welfare, management, and phenotyping applications in New Zealand deer farming systems.

Development

Activity collars were designed at AgResearch with the objective of producing a low-cost, adaptable unit that could be serviced locally to save cost, and time between deployments. It was necessary to develop units as commercially available units have several prohibitive limitations, namely:

- High cost of each unit.
- Proprietary limitations around data access and prediction algorithms.
- Restricted access to raw data which is critical for behavioural prediction purposes.
- Not specifically validated to detect behaviours in deer.
- Some limitations on flexibility to alter recording frequency.
- Redeployment timeframe uncertainty due to battery changeover etc.

The new activity collars were developed using commercially available electronics and assembled initially in house during the prototyping stages. They used a combination of sensors to help predict behaviour and capture location for interpretation of animal to animal and animal to landscape interactions. Once a unit was tested and proven larger scale production was achieved using a commercially available PCB manufacturer in China.

The final version of the activity collars were printed on a two-layer printed circuit board (PCB) and controlled by a EXPRSSIF 16MB microprocessor (EXP32-WROOM-32UE) with location captured using a Quectel L80-R GPS chip with built in antenna. Movement/acceleration were captured using a InvenSense 9-axis motion sensor (MPU-6050) with all data stored on an on-board SD card. The activity collars were powered by two Samsung Li-Ion 21700 cells in parallel. The units were programmed using open-sourced Arduino software with a USB to serial adaptor and cable.

The PCB and battery were housed within a 3D printed case using UV protected acrylonitrile styrene acrylate (ASA) filament and utilising acetone smoothing finishing to improve water durability. Collars were fitted around the neck of the animals with 23mm wide webbing and side clip buckles and secured with anti-slip tri-buckles.

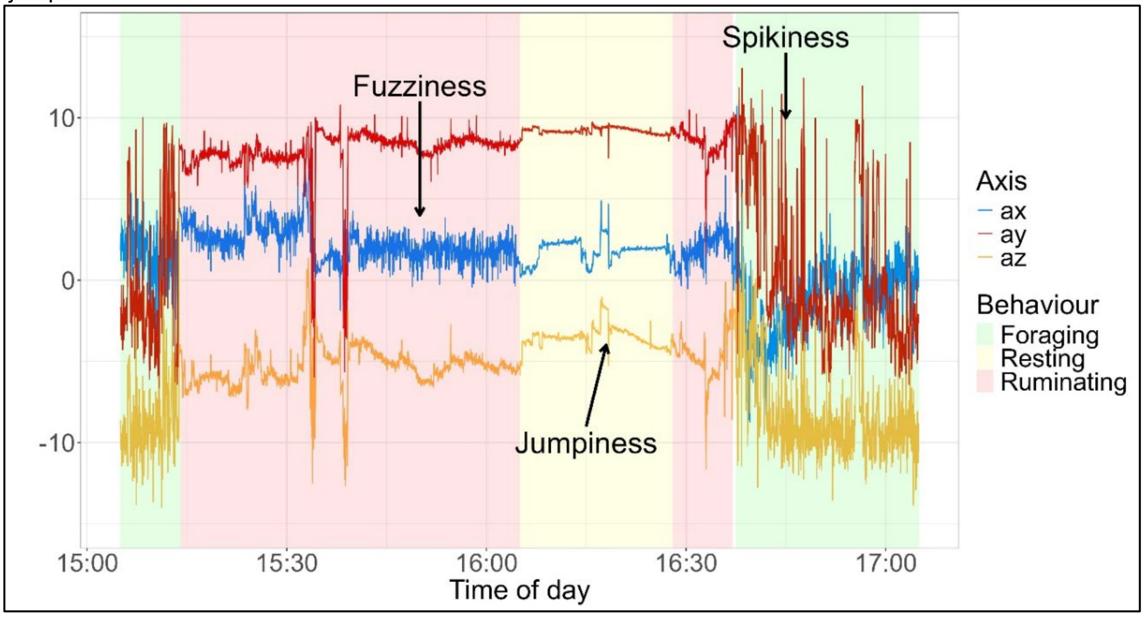
Validation

A research trial using 24 prototype activity collars fitted to 13-month-old red deer on the AgResearch Invermay deer farm was conducted. All animal manipulations were approved by the AgResearch Animal Ethics Committee in accordance with the provisions of the New Zealand Animal Welfare Act 1999, and the New Zealand Code of Welfare developed under sections 68-79. Animals were also fitted with uniquely coloured and numbered identification collars and observed by trained observers from an observation tower that was situated between ~300-500m across a small valley. The animals were observed over four two-hour periods per day for five days in February 2021 using 30-second instantaneous sampling on one focal animal per observer per two-hour period. Recorded behaviours were lying/standing/walking and eating/ruminating/grooming. If animals were not eating/ruminating/grooming or walking, they were considered to be resting.

Visual assessment of data indicated that behaviours should be relatively straight forward to predict using the accelerometer traces exclusively (Figure 1). Accelerometer data was downloaded and separated into two sets for training and validation purposes. Accelerometer data was processed using a rolling 30-second window to calculate ‘fuzziness’, ‘spikiness’ and ‘jumpiness’ (Figure 1). These features were passed through a classification tree to infer behaviours. Supervised learning was used to train the classification trees by matching observed data to accelerometer data using time stamps.

GPS data can be utilised to inform spatial interactions between individuals and landscape features, vegetation types and interactions between individual animals.

Figure 1. Accelerometer traces from three axes (red, blue, and yellow lines) with observed behaviours (shaded colour background) over a 2-hour period from one activity collar. “Fuzziness”, “spikiness”, and “jumpiness” features are annotated.



Current uses

The deer activity collars are currently being used to help capture foraging behaviours from ~180 red deer hinds that are being managed on two farming properties. The objective of this research is to identify animal behavioural syndromes to help align individuals to farming landscapes and systems. This research monitors the individuals repeatedly over several physiological periods across a two-year period with some individuals being transferred between farming properties in the second year to monitor transition and behavioural changes. This work has already demonstrated the considerable variation between individuals in time budgets, and utilisation of resources. This work is ongoing.

The deer activity collars are also being used to assess the welfare implications of deer specific management procedures. Behavioural changes captured by validated technology are considered a valid tool for capturing animal welfare metrics (Chapa *et al.* 2020). By using the activity collars, we can assess if the daily time spent foraging/resting/ruminating are affected by management procedures to get a better understanding of the impact of management decisions and procedures on animal welfare metrics.

Implications

As livestock farming becomes more data driven our dry stock enterprises will need to keep pace with dairy systems to remain competitive. Wearable technologies to measure, predict and interpret animal behaviour and activity offer opportunities to care for and manage our livestock at a scale and precision that agriculture has never had before even when living with livestock 24 hours a day. Having validated technology for deer that can capture subtle changes in animal behaviours creates many opportunities to refine our farming systems and assessing the impact that we have on the individual animal, the farm system, and the environment. This helps farmers to maintain their social license to farm through the demonstration of good welfare practices. Practicing large animal veterinarians should watch this space and look to take advantage of the opportunities it will present to have earlier interventions for good animal health and welfare. This will not only be on an individual level but whole herd and forward looking with data driven opportunities to improve animal health planning and management inputs.

References

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