A High-Resolution Analysis of Feeding Behaviours: Do Seconds Matter in Understanding Feed Intake Patterns of Beef Heifers?

**Application**

Using vision technologies to measure feeding behaviours and predict feed intakes in beef heifers can provide high resolution feeding behaviour and real time insights that can be used to support sustainable livestock management practices.

**Introduction**

Precision livestock technologies are essential for advancing animal health and welfare, these technologies enable continuous monitoring to identify issues such as lameness, oestrus and diseases. However, many existing Precision Livestock Farming (PLF) technologies focus on a limited set of variables. In feeding behaviour studies, systems often capture basic metrics like presence of an animal at the feeder and visit frequency at an hourly or daily rate, but do not track head movements whilst the animal is at the feeder. This is of importance because feeding behaviour has been linked to feed intake (Schwartzkopf-Genswein *et al*., 1999). While traditional observation methods can provide insights, they are labour-intensive and prone to errors (Sowell *et al*., 1998). Camera systems offer a less intensive solution, capable of monitoring behaviours of a group of animals at high resolutions, in real time, without physically attaching devices to animals (Porto *et al*., 2015). The integration of computer vision with high-resolution behavioural monitoring offers an opportunity to capture more nuanced behavioural patterns efficiently. The objective of this study was to utilise vision technologies to analyse feeding behaviour at a focused timescale and evaluate the predictive power for estimating feed intake in beef heifers. This work aims to contribute to the development of precision livestock farming techniques that can improve resource efficiency and sustainability in the beef industry.

**Materials and Methods**

An automatic recording system was developed to monitor the actions of five British Blue heifers, weighing 368.6 ± 27.1 kg, fed a total mixed ration (TMR). Images captured by the recording system were processed using computer vision techniques as outlined in Wager-Jones *et al*. (2024). The processed data from the vision system were linked with feed bin weight measurements, resulting in each second of observation having a corresponding image frame and feed bin weight. The frames were grouped over time to calculate durations of two variables: down events and down duration. For example, 10 consecutive frames showing the heifers with its head down were grouped as a 10-second duration, with the corresponding feed bin weight calculated as the mean of smoothed bin weights to reduce noise inherent in such systems. Observations of the heifers at the feed bin were further refined: if a "no\_animal" event occurred but lasted 5 seconds or less and was flanked by the same heifers’ "head down" events on either side, the "no\_animal" event was integrated into the same observation rather than treated separately. In total, 108 unique observations were obtained, with each observation representing a single feed bunk visit. For each observation, variables were calculated. The down\_events variable represented the total number of head-down events during the visit, while down\_duration captured the cumulative duration of all head-down events. The estimated\_intake was derived as the difference in feed bin weight (grams) before and after each visit. The relationship between estimated intake and the predictors, down\_events and down\_duration, was analysed to assess their significance. F-statistics were used to evaluate the overall significance of the model, and ANOVA was performed to determine the individual contributions of each predictor to the model's fit.

**Results**

The linear mixed-effects model evaluated the relationship between estimated feed intake and the predictors, down\_events and down\_duration, while accounting for random variability across individual heifers (heifers\_id). The model explained a substantial proportion of variance, with a marginal R2 of 0.686 and a conditional R2 of 0.689. Among the fixed effects, down\_events showed a significant positive association with estimated intake (Estimate = 53.43, p<0.001), indicating that an increase in the number of downward events is strongly correlated with higher feed intake. Conversely, down\_duration was not a significant predictor (Estimate = 0.51, p=0. 470). The random effect for heifers\_id had a standard deviation of 24.06, reflecting moderate variability in intake across individual heifers. ANOVA results confirmed that down\_events was a significant contributor to the model (F= 37.33, p < 0.001), while down\_duration didn’t contribute significantly.

**Conclusions**

This analysis underscores the significant role the number of down events during a feed bunk visit have in predicting feed intake. The lack of a significant relationship between down duration and feed intake implies that the total time spent with the head down is less predictive of intake than the occurrence of specific down events. These findings highlight the value of vision-based technologies in capturing detailed behavioural metrics that can be used to obtain predictions of feed intake from feeding behaviours and contribute to calculations of feed efficiency. Further research should investigate the specific characteristics of down duration and consider the potential influence of other behaviours that may occur during a down event, which could explain why down duration is not a reliable predictor of feed intake.

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