

Characterizing feed efficiency in Angus x Friesian beef cattle using precision livestock technologies

M. Roda¹, M. Verdú², A. Siurana¹, E. Armengol³, and L. Castillejos¹

¹*Animal Nutrition and Welfare Service (SNiBA), Department of Animal and Food Science, Autonomous University of Barcelona, 08193 Bellaterra, Spain*

²*Department of Animal Nutrition and Feed Industry, bonÀrea Agrupa, 25210 Guissona, Spain*

³*Instituto de Investigación en Inteligencia Artificial (IIIA – CSIC), Campus UAB, 08193 Bellaterra, Spain*

Maria.Roda@uab.cat

Abstract

Precision livestock farming (PLF) technologies enable continuous and individualized monitoring of performance traits (body weight, feed intake and feeding behaviour), facilitating the characterization of feed efficiency in beef cattle under intensive production conditions. In this study, 68 Black Angus x Friesian fattening bulls were monitored over 260-days using a single-space electronic feeder per pen and an automatic weighing scale integrated into a watering trough. The feed conversion ratio (FCR) exhibited the highest Spearman correlations with average daily gain (ADG: $\rho = -0.74$), followed by feed intake ($\rho = 0.48$), and body weight (BW: $\rho = 0.31$), whereas feeding behaviour parameters showed low correlations. Body weight was moderately correlated with feed intake ($\rho = 0.50$) and showed a weak negative correlation with ADG ($\rho = -0.17$). In contrast, feeding behaviour parameters were highly correlated with BW, eating rate was strongly correlated with BW ($\rho = 0.80$), whereas feeding time showed a moderate negative correlation ($\rho = -0.42$). Moreover, the evolution of ADG reached its peak around 300 kg BW (ADG = 1.8 kg/day) and declined as BW increased, whereas FCR increased progressively with BW. The relationship between FCR and BW was described using a simple linear model ($y = 0.0063x + 1.5942$; $r^2 = 0.68$). The data generated by PLF technologies provided detailed information for the characterization of feed efficiency, a necessary preliminary step for the development of predictive models.

Keywords: feed efficiency, feed conversion ratio, body weight, characterization, precision livestock farming, beef cattle

Introduction

The identification of factors determining feed efficiency is essential for optimizing production and profitability in beef cattle industry (Aboshady et al., 2024). Precision livestock technologies enable continuous, real-time monitoring of performance and behaviour traits, allowing the collection of large volumes of data. Such data facilitate detailed phenotypic characterization, which is a necessary and crucial step for identifying associations among traits and for building predictive models (Hassán Vázquez et al., 2022) to identify the most feed efficient animals, enabling the detection of high-performing individuals and supporting breeding and management programs. The

objective of this study was to characterize feed efficiency in Black Angus x Friesian bulls raised under an intensive production system using data obtained from precision livestock devices.

Material and methods

This study was conducted on a commercial beef farm (Granja Mases, Talavera, Spain) using 68 crossbred Black Angus x Friesian bulls (180 ± 25.8 kg initial BW; 144 ± 16.4 days of age). Animals were distributed into four pens (15-19 animals per pen) and monitored for 260 days. Each pen was equipped with a single-space electronic feeder (bonÀrea Agrupa, Guissona, Spain), which recorded individual feed intake and feeding behaviour. Daily body weight (BW) was monitored using an automated scale integrated into a watering trough (DigitiAnimal, Madrid, Spain). Additionally, each animal wore a neck-mounted accelerometer (CowScout Neck, GEA Farm Technologies, Bönen, Germany) to record rumination time.

The following productive parameters were calculated from PLF technology: BW (kg), average daily gain (ADG; kg/day), feed intake (kg/day), feeding time (min/day), number of meals (meals/day), eating rate (g/min), meal size (kg), and feed conversion ratio (FCR; kg/kg). Statistical analyses were performed in R software (R v3.5.1, R Foundation for Statistical Computing, Vienna, Austria)

Results and Discussion

A total of 14,579 individual records were collected. The Spearman correlation map (Figure 1) revealed that FCR was most strongly correlated with ADG ($\rho = -0.74$), followed by feed intake ($\rho = 0.48$) and BW ($\rho = 0.31$). Feeding behaviour traits exhibited low to moderate correlations with FCR (eating rate $\rho = 0.35$; meal size $\rho = 0.23$; number of meals $\rho = 0.20$; feeding time $\rho = 0.11$). Rumination time showed only a weak correlation with FCR ($\rho = 0.09$). Body weight showed a moderate positive correlation with feed intake ($\rho = 0.50$), and a weak negative association with ADG ($\rho = -0.17$). In contrast, feeding behaviour traits were more strongly related to BW, particularly eating rate ($\rho = 0.80$), whereas feeding time was moderately and negatively associated with BW ($\rho = -0.42$). All correlations were statistically significant ($p < 0.01$).

Overall, ADG appeared to be the variable most strongly associated with feed efficiency, showing the highest correlation with FCR. Feed intake showed a moderate correlation with FCR, indicating that although intake is related to feed efficiency, it does not fully explain the observed variability, suggesting that additional factors may also contribute. Feeding behaviour traits generally showed weaker associations with FCR. Among them, eating rate displayed the strongest correlation and was positively associated with FCR, which may indicate that higher ingestion rates tend to occur in less efficient animals. Rumination time showed only a weak association with feed efficiency, suggesting a limited contribution of this variable to the observed variation in FCR. Body weight showed a strong positive correlation with eating rate and a negative correlation with

feeding time, indicating that heavier animals tend to feed more rapidly while spending less time at the feeder.

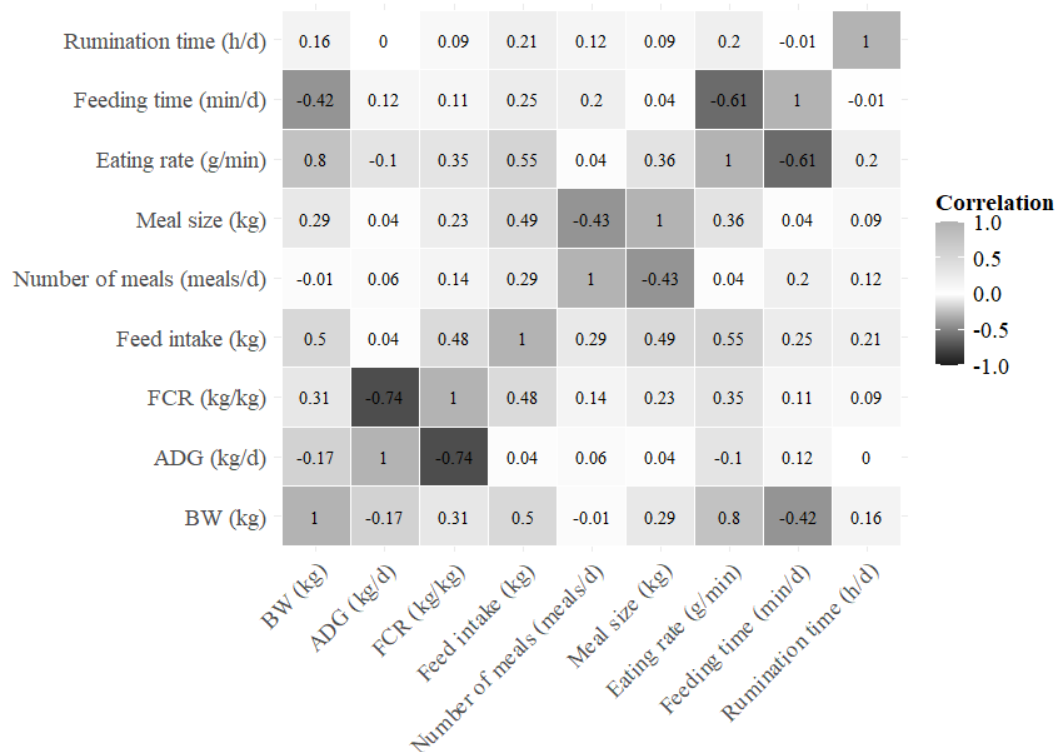


Figure 1: Spearman correlation coefficients (p-value < 0.01) between body weight (BW), average daily gain (ADG), feed conversion ratio (FCR), feed intake, number of meals, meal size, eating rate and feeding time.

In this context, the evolution of FCR and ADG in relation to BW showed opposite patterns (Figure 2). ADG increased with BW up to around 300 kg, peaking at 1.8 kg/day, and then declined as BW continued to increase. In contrast, FCR remained low at lighter weights and progressively increased with increasing BW. This relationship between FCR and BW was well described by a simple linear model ($y = 0.0063x + 1.5942$; $r^2 = 0.68$).

This trend is consistent with the strong negative correlation between FCR and ADG, indicating that animals with higher growth rates generally exhibited more efficient feed conversion. Moreover, the moderate correlation between FCR and feed intake, together with the weaker associations observed for feeding behaviour traits and rumination, suggests that although these variables contribute to feed efficiency, ADG captures most of the variation in efficiency across the growth trajectory. The patterns observed in Figure 2 reinforce this interpretation, as the lowest FCR values coincide with the BW range where ADG reaches its peak.

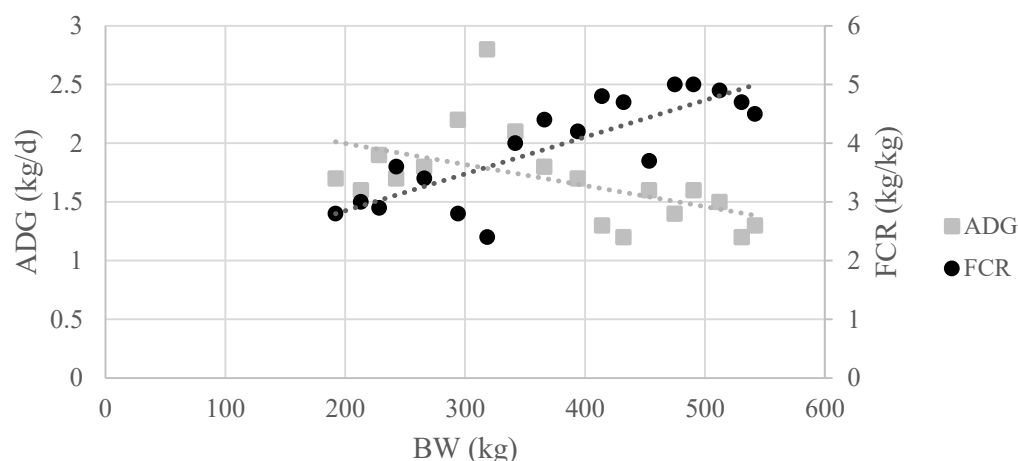


Figure 2: Scatter plot of body weight (BW) against average daily gain (ADG) and feed conversion ratio (FCR). Each point corresponds to the median value for a 14-day period. Dashed and dotted lines represent linear regression fits.

Conclusions

Precision livestock technologies provide detailed insights into the evolution of individual performance parameters throughout the fattening period. These results indicate that productive traits have a greater influence on feed conversion rate than feeding behaviour ones. Continuous monitoring using precision devices allows the characterization of individual animals, facilitating the identification of the most feed-efficient animals and providing a robust basis for developing predictive models of feed efficiency and supporting management decisions.

Acknowledgements

The authors acknowledge the financial support from the Ministerio de Ciencia e Innovación and the FEDER fund (SMARTBEEF PID2021-126987OB-I00).

References

- Aboshady, H. M., Jorge-Smeding, E., Taussat, S., & Cantalapiedra-Hijar, G. (2024). Development and validation of a model for early prediction of residual feed intake in beef cattle using plasma biomarkers. *Animal*, 18(11), 101354.
- Hassán Vásquez, J. A., Maroto Molina, F., & Guerrero Ginel, J. E. (2022). Integration of precision livestock farming and remote sensing to enhance grazing management in agrosilvopastoral systems: Practical considerations. In T. Banhazi, V. Halas, & F. Maroto-Molina (Eds.), *Practical precision livestock farming – Hands-on experiences with PLF technologies in commercial and R&D settings* (pp. 175–191). Wageningen Academic Publishers.