



13 S 496 - Development, Calibration and Validation of Feed Intake Methodology to Rapidly Screen Dairy, Beef and sheep for feed Intake and Efficiency

Final Report

SUMMARY

With competition between livestock and humans for land to produce food for a rapidly growing human population, FCE within our livestock production systems has never been more important. The potential for genetic improvement of FCE in ruminants has been demonstrated under research conditions, but the means to attain large quantities of feed intake information on individual animals, particularly grazing livestock, has to date proven elusive. To derive genetic evaluations for FCE, the ability to capture accurate information pertaining to feed intake routinely is necessary. This study aimed firstly to determine the impact of current national breeding goals in dairy, beef and sheep on feed intake and efficiency. Secondly, the study aimed to explore and validate means of measuring feed intake (and ultimately FCE) in dairy, beef and sheep. A third objective was to evaluate the appropriateness of recording feed intake/FCE indoors on an energy-rich diet as an indication of intake or FCE in grazing beef animals as currently practiced by the ICBF to derive breeding values for these traits for beef cattle.

The results provide assurance with regard to the sustainability of selection using our national breeding objectives across species in the context of DMI and the compatibility of resultant genetics with our grass-based production systems. The research does, however, also highlight the real challenge associated with recording/predicting individual DMI in a grazing environment. Consequently the routine direct derivation of feed efficiency remains a considerable challenge in the context of grazing livestock. However, green shoots by way of opportunity have been identified and future research may yield more conclusive outcomes.

KEYWORDS

Feed intake measurement

ACRONYM

RAPIDFEED

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Section 1 - Research Approach & Results

Start Date

01 January 2014

End Date

31 May 2019

Research Programme

Research Stimulus Fund

TRL Scale

TRL 3: Experimental Proof of Concept

NRPE Priority area

Sustainable Food Production and Processing

Total DAFM Award

€679,906.00

Total Project Expenditure

€653,459.00

Rationale for undertaking the Research

Ruminant feed costs in Ireland account for 60 – 80% of total variable costs of production. Intensive systems of livestock production utilise large quantities of high-energy crops and cereals. The world's human population is increasing rapidly and demand for food is expected to rise by 70% come 2050 compared with 2010. Competition between livestock and humans for land to grow food is therefore prompting debate.

Animals that efficiently convert feed to product can improve both profitability and reduce environmental footprint. Estimation of feed intake, however, has historically been a costly and labour intensive procedure, especially within grazing systems, and is effectively prohibitive outside of a research environment. For this reason the ability to generate genetic evaluations for FCE as a direct selection trait has been unattainable anywhere in the world. To derive genetic evaluations for FCE, the ability to capture routine information pertaining to feed (energy) intake must be possible. Data on most energy sinks are available or easily attainable (milk yield parameters, live weight, live weight gain etc). Hence, if recording of feed intake or a suitable proxy was to be developed, a genetic value for FCE as a direct selection trait would logically follow.

Breeding values for feed intake and FCE in beef cattle are generally derived indoors on high-concentrate diets as is the case in Ireland with ICBF using Tully and the beef 'Terminal Index'. This is not appropriate where the majority of the animal's life is spent consuming grass, Ireland's competitive advantage.

Methodology

Intake, efficiency and feeding behaviour characteristics of Holstein-Friesian cows of divergent EBI were evaluated using the Next Generation herd at Moorepark, a sentinel research herd investigating the anticipated phenotypic performance of futuristic dairy cows selected using EBI.

Intake, efficiency and feeding behaviour characteristics of lactating suckler cows using Teagasc Maternal and Derrypatrick herds, representing diverse genetic merit based on REPLACEMENT Index and replacement strategy (of dairy cross or suckler beef origin).

Intake and efficiency of lactating ewes was undertaken at Teagasc Athenry working with ewes of contrasting prolificacy within their research flock.

Measurements to determine the potential to develop a model to predict DMI of grazing dairy cows, beef cows and ewes were conducted on the above three herds/flock. The suite of measurements was comprehensive spanning ingestive behavior, body measurements, thermal imaging, heart rate and blood pressure to predict dry matter intake in grazing dairy, beef cows.

A further model to predict DMI (grazing dairy cows only) was developed incorporating infrared reflectance spectroscopy analysis (MIRS of routine milk samples and NIRS of dried faeces which form part of the n-alkane technique used to estimate intake under research conditions).

In order to evaluate the appropriateness of recording feed intake/FCE indoors on an energy-rich diet as an indication of intake or FCE in grazing beef animals as currently practiced by the ICBF to derive breeding values for these traits for beef cattle the repeatability of feed intake and feed efficiency in growing beef cattle offered high-concentrate, grass silage and pasture-based diets was undertaken using the progeny of the maternal herd at Teagasc Grange using intake determined at Grange and in Tully (ICBF).

Project Results

Dry matter intake did not differ between ELITE (extremely high EBI) cows and cows of National Average EBI but intake capacity, expressed as DMI/100 kg body weight, was greater with ELITE cows. Milk solids/DMI and NEL/NEI-NEM and NEI/Milk solids yield, indicated a slight reduction in the utilization of ingested energy for milk production with the ELITE cows. These results are considered favourable as it manifested as a more positive energy balance and enhanced robustness, longevity and overall lifetime efficiency.

Replacement index had no effect on DMI. There was also no significant effect of genetic merit on feed efficiency. Cows sourced from dairy herds (BeefxDairy cross;BDX), however, did have higher daily DMI but produced more daily milk yield and produced weanlings that were 17 kg heavier than cows originating from suckler beef herds. In addition efficiency as determined by milk yield per 100 kg BW, milk yield per unit grass DMI and grass DMI per 100 kg BW were all more favourable for the beef cows of dairy cross in origin.

High prolificacy sheep had numerically lower intakes compared with medium prolificacy sheep. The high prolificacy sheep also had numerically higher milk yields and a superior feed efficiency at converting feed to milk and numerically higher lamb output.

Despite the comprehensive measurements, rumination mastication rate was the only trait identified that could increase the accuracy of DMI prediction in grazing lactating dairy cows, increasing R² by 0.015 to 0.81. In beef cows the inclusion of five variables; width at pins, full body depth, rumination mastication's, central ligament and rump width, in addition to milk yield, body weight, parity and maternal origin, increased the predictability of DMI by 0.29 to a coefficient of determination of 0.58 when compared to a model containing milk yield, body weight, parity and maternal origin only. A similar analysis with sheep found no significant relationships but could be due in part at least to the limited size of the sheep data set, and/or a consequence of the difficulty posed by conducting these measurements on large numbers of sheep. Consequently the routine direct derivation of feed efficiency remains a considerable challenge in the context of grazing livestock. However, green shoots by way of opportunity have been identified and future research may yield more conclusive outcomes.

Equations developed incorporating Infrared Reflectance Spectroscopy concluded the incorporation of MIRS analysis in combination with known animal energy sinks and status traits is proposed as the most promising due to its routine use in milk recording of dairy cows.

Analysis of the repeatability of feed intake and feed efficiency in beef cattle offered grass silage, pasture and high-concentrate based diets across 3 successive dietary test periods suggested evaluating animals for both feed intake and efficiency indoors on high-concentrate diets, as currently practiced by ICBF at Tully, may not reflect phenotypic performance when the basal diet is grazed grass and warrants further investigation. These implications may also extend to derivation of breeding values for greenhouse gas emissions.

Section 2 - Research Outputs

Summary of Benefits / Improvements of Project Findings

Ultimately, the success of pasture-based dairy, beef and sheep production in Ireland is reliant on the selection of animals capable of efficiently converting a predominantly grazed grass and grass silage-based diet to product cost effectively. The research highlights the challenges associated with predicting individual DMI routinely in a grazing environment and so direct derivation of feed efficiency remains a considerable challenge. However, green shoots by way of opportunity have been identified and future research may yield more conclusive outcomes. Aspects of grazing and rumination behavior could possibly be used as indicator traits to derive feed intake and improvements in FCE.

The research conducted does on the other hand provide real assurance with regard to the sustainability of current selection using our national breeding objectives across species in terms of the compatibility of resultant genetics with our grass-based production systems. This does, however, imply that care is needed not to undermine this compatibility where changes to these indexes are made in the future, e.g., while selection to improve daily FCE might seem a plausible ambition, to attempt to do so via a reduction in DMI while maintaining or increasing output could very likely negatively impact energy balance and consequently compromise robustness and lifetime efficiency.

One particular area highlighted for further research is the appropriateness of evaluating animals for both feed intake and efficiency indoors on high-concentrate diets, as currently practiced by ICBF at Tully, which may not reflect phenotypic performance when the basal diet is grazed grass. The implications likely also extend to the generating of breeding values for greenhouse gas emissions as feed intake and methane production is closely linked. This warrants further investigation.

Summary of Staff Outputs

Research Output	Male	Female	Total Number
PhD Students	2	1	3
Research Technicians/ Assistants	0	1	1

Summary of Academic Outputs

Research Outputs	Total Number	Details
Publications in Peer Reviewed Scientific Journals	7	Almost all of the research results outlined have been published in peer reviewed articles in the highest ranking international journals: Journal of Dairy Science (2), Animal (3), Livestock Science (1), Irish Journal of Agricultural and Food Research (1)
Peer Reviewed Conference Papers	7	Research results from the current research programme were presented at various scientific forums: British Society of Animals Science (2018), European Grassland Federation Conference (2018).
PhD Theses	3	The research described contributed to chapters/peer review papers within 3 different PhD theses. The students; Morgan O'Sullivan (dairy), Ben Lahart (dairy) and Simone McCabe (beef).
Other	4	Presentations at Open days at Teagasc Moorepark and Teagasc Grange, visitation to Moorepark by delegates of European Grassland Federation Conference (2018) and various visiting groups to Teagasc.

Intellectual Property

N/A

Summary of other Project Outputs

N/A

Potential Impact related to Policy, Practice and Other Impacts

Impact	Details
Industry	<p>The research results provide real assurance with regard to the sustainability of current selection using our national breeding objectives across species, the Economic Breeding Index (EBI) in the case of dairy cows and the Replacement Index in the case of beef cows, in terms of the compatibility of resultant genetics with our grass-based production systems. The results highlight clear favourable selection responses to selection using the Irish National Breeding objective, the Economic Breeding Index (EBI). Absolute daily dry matter intake (DMI) did not differ between cows of High and National Average EBI but intake capacity, a trait deemed very important in the context of pasture-based milk production, was higher the high EBI cows. There was identified, however, a slight reduction in the utilization of ingested energy for milk production with high EBI cows but this was considered favourable as it manifests as a more positive energy balance and enhanced robustness, longevity and overall lifetime efficiency.</p> <p>In beef no effect of genetic merit for Replacement Index on intake or efficiency was observed. Cows of beef origin had lower DMI and weanling weight but similar DMI per 100 kg weanling weight when compared to beef cows of dairy origin.</p> <p>In sheep, the research undertaken confirmed the potential to determine individual DMI for sheep under research conditions using the n-alkane technique. It also demonstrated that variation in DMI and consequently production efficiency does exist among individual ewes and substantiates the biological mechanisms regulating efficiency in high prolificacy ewes.</p>

With regard to routine prediction of individual DMI, statistical analyses using a comprehensive range of animal measurements demonstrated limited opportunity to enhance DMI prediction of grazing lactating dairy cows over and above the predictability of known energy sinks and status traits such as milk production, live weight and parity. A similar analysis conducted on lactating beef cows demonstrated some potential to improve the prediction using a model including body measurements and grazing behaviour traits in addition to cow milk yield, weight, parity, calving date and maternal origin (beef or dairy). However, challenges around applicability are acknowledged.

Equations developed incorporating Infrared Reflectance Spectroscopy (MIRS and NIRS) offers some potential to improve the prediction of individual cow DMI of lactating dairy cows under grazing conditions. MIRS analysis of milk in combination with known animal energy sinks and status traits is proposed as the most promising due to its routine use in milk recording of dairy cows.

The practice of evaluating cattle for both feed intake and feed efficiency indoors on concentrate-based diets may not reflect the phenotypic performance when consuming conserved forage-based diets indoors or when grazing pasture. The implications likely also extend to the generating of breeding values for greenhouse gas emissions as feed intake and methane production is closely linked. Further research in this area is suggested to validate this finding/recommendation.

Dissemination Activities

Activity	Details
Seminars at which results were presented	Teagasc internal research programme/project reviews 2019

Knowledge Transfer Activities

Identify knowledge outputs generated during this project.	N/A
Identify any knowledge transfer activities executed within the project.	N/A
List any impacts resulting from the knowledge transferred during the project.	Enhanced confidence in the use of breeding indexes to identify superior livestock as the results clearly highlight that The research results provide real assurance with regard to the sustainability of current selection using our national breeding objectives across species in terms of the compatibility of resultant genetics with our grass-based production systems.

Section 3 - Leveraging, Future Strategies & Reference

Leveraging Metrics

N/A

Future Strategies

N/A

Project Publications

- O'Sullivan, M., Dillon P., O'Sullivan K., Pierce K.M., Galvin N., Egan M. and Buckley F. (2019). Intake, efficiency, and feeding behavior characteristics of Holstein-Friesian cows of divergent Economic Breeding Index evaluated under contrasting pasture-based feeding treatments. J Dairy Sci. 102: 8234-8246.

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2. Williams, M., Prendiville R., O'Sullivan K., McCabe S., Kennedy E., Liddane M., and Buckley F. (2019). Developing and validating a model to predict the dry matter intake of grazing lactating beef cows. *Animal*. 13:11, 2639-2649.
 3. Lahart, B., McParland, S., Kennedy E., Boland T., Condon T., Williams M., Galvin N, McCarthy B. and Buckley F. (2019). Predicting the drymatter intake of grazing dairy cows using infrared reflectance spectroscopy analysis. *J Dairy Sci*. 102: 8907-8918.
 4. McCabe, S., McHugh, N., O'Connell, N. and Prendiville, R. (2019). Comparative grazing behaviour of lactating suckler cows of contrasting genetic merit and genotype. *Livestock Science*, 220, 129-136. doi: <https://doi.org/10.1016/j.livsci.2018.12.002>
 5. Lahart, B., Prendiville R., Buckley F., Kennedy E., Boland T.M., and McGee M. (2020). The Repeatability of Feed Intake and Feed Efficiency in Beef Cattle Offered High-Concentrate, Grass Silage and Pasture-Based Diets. *Animal* doi:10.1017/S1751731120000853.
 6. McCabe, S., McHugh, N., O'Connell, N.E. and Prendiville, R. (2020). Evaluation of production efficiencies at pasture of lactating suckler cows of diverse genetic merit and replacement strategy. *Animal*, 14: 8 1768-1776.
 7. Lahart, B., Kennedy E., Williams M., Boland T.M., O'Sullivan K., Linnane M, and Buckley F. (2020). Exploring the potential of grazing behavior, body measurements, thermal imaging, heart rate and blood pressure to predict dry matter intake in grazing dairy cows. *Irish Journal of Agricultural and Food Research*. In Press - due to be published shortly.