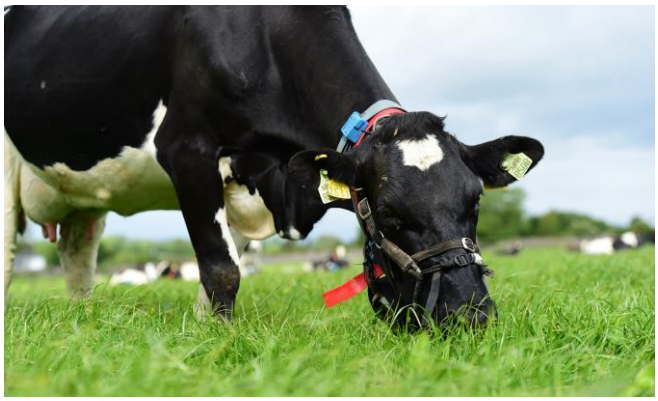
Project number: 6511
Funding source: Department of Agriculture, Food and The Marine & Teagasc RAPIDFEED)
Date: July 2020
Project dates: Jan 2014 – May 2019

Development, calibration & validation of feed intake methodology to rapidly screen dairy, beef & sheep for feed intake & efficiency (RAPIDFEED)



Key external stakeholders:
Irish dairy farmers, ICBF, AI/Milk Recording, consultancy agencies

Practical implications for stakeholders:

- 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.
- In beef, while contrasting replacement strategies (beef v dairy origin) did affect DMI and production efficiency, 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.
- 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.
- 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.

Main results:

- Intake did not differ between ELITE cows and cows of National Average EBI but intake capacity, expressed as DMI/100 kg body weight, was greater with ELITE cows. However, 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. This was considered favourable as it manifested as a more positive energy balance and enhanced robustness, longevity and overall lifetime efficiency.

Contact Dr Frank Buckley Email: frank.buckley@teagasc.ie.

- Replacement index had no effect on feed intake with high and low Replacement Index beef cows having similar DMI's (11.9 kg and 12.1 kg, respectively). There was also no significant effect of genetic merit on feed efficiency. Cows sourced from dairy herds (BeefxDairy cross;BDX) had 0.8 kg higher daily DMI, produced 1.8 kg more daily milk yield (P<0.001), had a 0.8 UFL greater daily energy requirement for lactation and produced weanlings that were 17 kg heavier than cows originating from suckler beef herds. Subsequent efficiency variables of milk per 100 kg BW (P<0.001), milk yield per kg GDMI (P<0.001) and GDMI per 100 kg BW (P<0.001) were more favourable for BDX.
- High prolificacy sheep have numerically lower intakes compared with medium prolificacy sheep. The high prolificacy sheep also have numerically higher milk yields and a superior feed efficiency at converting feed to milk (p<0.01) and numerically higher lamb output.
- Despite the comprehensive measurements undertaken, rumination mastication rate was the only trait identified that could increase the accuracy of DMI prediction upon external validation, increasing (P<0.05) R^2 by 0.015 to 0.81. In beef the inclusion of five variables (P<0.05); 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.
- Equations were also developed incorporating Infrared Reflectance Spectroscopy (MIRS and NIRS). 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. The implications likely also extend to the generating of breeding values for greenhouse gas emissions as feed intake and methane production is closely linked.

Opportunity / Benefit:

The research provides assurance with regard to the sustainability of selection using our national breeding objectives across species in terms of the compatibility of resultant genetics with our grass-based production systems. The research also highlights the challenges associated with predicting individual DMI in a grazing environment. What is very clear from the research undertaken is that prediction of DMI and 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.

Collaborating Institutions:

UCD, ICBF

Teagasc project team:	Prof. Frank Buckley (PI), Dr. Emer Kennedy, Dr. Sinead McParland
External collaborators:	Prof. Tommy Boland, University College Dublin, Ms. Kathleen O'Sullivan, University College Cork

1. Project background:

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 (energy) intake routinely must be possible. The study aimed firstly to determine the impact of current national breeding goals in dairy, beef and sheep on feed intake and efficiency. In addition the study aimed to identify and validate low-cost methods of measuring feed intake (and ultimately FCE) in dairy, beef and sheep. Three genetically divergent research herds (and flock) in dairy, beef (plus the national beef

Contact Dr Frank Buckley Email: frank.buckley@teagasc.ie.

performance test station) and sheep were used. A further three independent research herds (and flock) were used for validation. 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.

2. Questions addressed by the project:

- Does selection for EBI in dairy, Replacement index in beef and Prolificacy in sheep impact on grass DMI and FCE?
- Is it possible to identify traits that can be easily measured that may be incorporated into an equation to enhance the predictability of DMI of lactating dairy cows, beef cows and ewes under grazing conditions?
- Is it appropriate to generate breeding values for DMI/FCE for grazing beef cattle from data generated indoors on an energy-rich diets?

3. The experimental studies:

- Intake, efficiency and feeding behaviour characteristics of Holstein-Friesian cows of divergent EBI evaluated under contrasting pasture-based feeding treatments.
- Evaluation of production efficiencies among lactating suckler cows of diverse genetic merit and replacement strategy at pasture.
- Exploring the potential of ingestive behavior, body measurements, thermal imaging, heart rate and blood pressure to predict dry matter intake in grazing dairy cows.
- Developing and validating a model to predict the dry matter intake of grazing lactating beef cows.
- Predicting the dry matter intake of grazing dairy cows using infrared reflectance spectroscopy analysis.
- Intake and efficiency of lactating ewes of contrasting prolificacy.
- The repeatability of feed intake and feed efficiency in beef cattle offered high-concentrate, grass silage and pasture-based diets.

4. Main results:

- Intake did not differ between ELITE cows and cows of National Average EBI but intake capacity, expressed as DMI/100 kg body weight, was greater with ELITE cows. However, 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. This was 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 feed intake with high and low Replacement Index beef cows having similar DMI's (11.9 kg and 12.1 kg, respectively). There was also no significant effect of genetic merit on feed efficiency. Cows sourced from dairy herds (BeefxDairy cross;BDX) had 0.8 kg higher daily DMI, produced 1.8 kg more daily milk yield ($P<0.001$), had a 0.8 UFL greater daily energy requirement for lactation and produced weanlings that were 17 kg heavier than cows originating from suckler beef herds. Subsequent efficiency variables of milk per 100 kg BW ($P<0.001$), milk yield per kg GDMI ($P<0.001$) and GDMI per 100 kg BW ($P<0.001$) were more favourable for BDX.
- High prolificacy sheep have numerically lower intakes compared with medium prolificacy sheep. The high prolificacy sheep also have numerically higher milk yields and a superior feed efficiency at converting feed to milk ($p<0.01$) and numerically higher lamb output. Equations developed and validated for dairy and beef incorporated.
- Of 94 and 33 variables tested in beef and dairy, respectively, (body measurements, linear type scoring, grazing behaviour and thermal imaging to predict DMI in combination with known biologically plausible adjustment variables and known energy sinks and status traits) 32 showed an association with DMI ($P<0.25$) in beef and 10 in dairy. In the beef analysis five variables ($P<0.05$); width at pins, full body depth, rumination mastication's, central ligament and rump width, were retained in the model in addition to milk yield, body weight, parity and maternal origin. Upon validation using an independent beef herd inclusion of these variables in the model increased the predictability of DMI by 29 percentage units (coefficient of determination = 0.58) when compared to a model containing milk yield, body weight, parity and maternal origin only. Rumination mastication rate was the only trait identified that could increase the accuracy of DMI prediction in dairy cows upon external validation, resulting in a 1.5 percentage unit increase in R2 (0.81). No significant relationships were observed with the sheep data set. This could be due in part to the limited size of the sheep data set, itself a consequence of the difficulty posed by the feasibility of measuring intake

Contact Dr Frank Buckley Email: frank.buckley@teagasc.ie.

at pasture and conducting these measurements on large numbers of sheep.

- Equations developed incorporating Infrared Reflectance Spectroscopy (MIRS and NIRS) suggest the incorporation of MIRS in combination with known animal energy sinks and status traits may offer potential to predict DMI of grazing dairy cows. From a practical perspective it is routinely used in milk recording of all milk recorded 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. The implications likely also extend to the generating of breeding values for greenhouse gas emissions as feed intake and methane production is closely linked.

5. Opportunity/Benefit:

The research provides assurance with regard to the sustainability of selection using our national breeding objectives across species in terms of the compatibility of resultant genetics with our grass-based production systems. The research also highlights the challenges associated with predicting individual DMI in a grazing environment. What is very clear from the research undertaken is that prediction of DMI and 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.

6. Dissemination:

During the life time of this project, two open days were held at Moorepark. Many discussion group visits, scientific and popular press articles and presentations as well as in-service training to Teagasc Advisory staff all served to deliver the key findings from this research to relevant stakeholders.

Main publications:

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

Lahart B., S. McParland, E. Kennedy, T. M. Boland, T. Condon, M. Williams, N. Galvin, B. McCarthy, and F. Buckley. 2019. Predicting the dry matter intake of grazing dairy cows using infrared reflectance spectroscopy analysis. *Journal of Dairy Science,* 102: 8907-8918.

Lahart B., R. Prendiville, F. Buckley, E. Kennedy, S. B. Conroy, T. M. Boland, M. McGee. 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.

7. Compiled by: Prof Frank Buckley

Contact Dr Frank Buckley Email: frank.buckley@teagasc.ie.