Project number: 6159
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Developing genetic tools to mitigate the environmental impact of dairy systems

Key external stakeholders:

The Irish Cattle Breeding Federation (ICBF)
Scientists
European breeding industry

Practical implications for stakeholders:

This study

- Developed a an accurate dynamic, mechanistic, empirical and stochastic model of dairy cattle to model farm production systems which may subsequently be used in decision support tools for Ireland
- Concluded that significance genetic variation in maintenance efficiency existed in growing cattle and developed novel statistical approaches to facilitate better exploitation of such variability in breeding programs

Main results:

- Dairy farm production systems can be accurately modeled using dynamic, mechanistic, empirical and stochastic model
- Heritable genetic variation in maintenance efficiency in growing cattle exists

Opportunity / Benefit:

- That the developed herd dynamic and associated models were accurate and may be effectively used in decision support tools
- Exploitable genetic variation in maintenance efficiency in growing animals exist and a novel approach to effectively capturing this variation was developed; this approach can be also applied to lactating dairy cows

Collaborating Institutions:

Irish Cattle Breeding Federation, INRA, SRUC, Wageningen University

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1. Project background:

The EU25 produce approximately 132 million tonnes of milk from 24.3 million cows on 1.76 million farm holdings. Ruminant animals account for up to 20% of the world methane (CH4) production with the EU25 dairy population producing approximately 3.2 million tonnes of CH4 per year. Many EU countries have specific and binding commitments relating to the reduction of greenhouse gas (GHG) emissions, and all sectors of the economy are coming under increasing scrutiny in relation to their share in the overall emissions target. Little research has been completed on the role of dairy cow genetics to reduce dairyGHG emissions, particularly considering the role of genetics in the whole farming system, including feeding strategy and management policies (e.g., energy balance, housing periods, fertilisation and manure management). GREENHOUSEMILK helped to increase the understanding around the role of energy efficiency and partitioning in the overall GHG output of dairy systems. Innovative tools were developed in GREENHOUSEMILK to help farmers' select "environmentally friendly" bulls to suit their system and how to manage those bulls' daughters in an appropriate manner. It harnessed statistical and genetic tools to elucidate the genetics of emissions in dairy cattle, and developed innovative and integrative tools that address the environmental impact of dairy farming, thus underpinning a high priority policy area.

2. Questions addressed by the project:

- The accuracy of modelling farm production systems using a dynamic, mechanistic, empirical and stochastic model of dairy cattle
- Whether inter-animal genetic variation existence in maintenance requirements for growing animals and how to best model and exploit such variability in breeding programs

3. The experimental studies:

- This study was desktop based
- A Herd Dynamic Milk model was developed in C++.
- The model was validated against experiments conducted both in Ireland and in France between 2008 and 2011
- BCS and BCS change were simulated in an innovative way in the model. The energy intake by the cow was allocated to the milk production or to a regain of BCS depending on the milk potential of the animal and the lactation stage. If the cow can produce more milk than what is possible from the feed intake, the cow will mobilise to permit/compensate for the lack of feed ingested. If the feed ingested permits a higher milk production than the theoretical milk yield the cow will gain BCS and also produce more milk than their theoretical potential allows;
- The Moorepark Grass Growth Model and the Moorepark Dairy System Model were also linked to the herd dynamic model
- Alternative phenotypic and genetic statistical models were applied to a dataset of 1,963 growing bulls of2 British and 3 Continental breeds from the ICBF national performance test station in Tully.
- The novel aspect of this study on growing animals was the use of a mixed model framework to quantify the heritable inter-animal variation in the partial regression coefficients on the energy expenditure traits within the RFI equation.

4. Main results:

- An increase in theoretical milk yield induces an increase in milk production per cow. The increase was within the range of previously published studies;
- An increase in herbage allowance induces an increase in milk production. The increase is higher for higher producing cows with the increase within the range of previous studies;
- The addition of concentrate in the diet induced an increase in the milk production. The increase is higher for cows with higher milk yield potential and when there is a lower herbage allowance. The increase was within the range of previous studies

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- The pasture based herd dynamic model is flexible and permits the simulation of a whole range of different grazing systems and scenarios; the model also allows for the inclusion of supplementation if and when required depending on the management rules.
- An increase in grazing intensity increases the milk production per hectare (average increase of 1,495 kg of milk per ha) while decreasing the milk production per animal (average decrease of 108 kg of milk per lactation);
- The increase of concentrate increases the milk production per hectare and per animal; In general as stocking rate increased there was an increase in profitability while the increase of concentrate supplementation led to a decrease in profitability;
- The variation of concentrate and milk price altered some of the conclusions, with the increase of the concentrate supplementation becoming beneficial at high grazing intensity in case of a very low concentrate prices and/or high milk prices;
- Heritable genetic variation in individual animal regression coefficients for metabolic live weight existed in the growing beef animals. No significant genetic variation in animal-level regression coefficients for growth or body fat level, however, existed in the study population.
- Estimated breeding values for the random regression coefficient could be useful phenotypes in themselves for studies wishing to elucidate the underlying mechanisms governing differences among animals in RFI.

5. Opportunity/Benefit:

- The developed herd dynamic and associated models are accurate and may be effectively used in decision support tools
- Exploitable genetic variation in maintenance efficiency in growing animals exist and a novel approach to effectively capturing this variation was developed

6. Dissemination:

International conferences

Presented at many international conferences, invited and contributed, such as the European Association of Animal Production, INTERBULL, ICAR, Greenhouse Gas and Animal Agriculture, Computational Methods for Systems Biology, American Dairy Science Association Annual meeting, and the World Congress on Genetic Applied to Livestock Production

National Conferences and seminars

Presented at the Agricultural Research Forums through the duration of the project

Main publications:

E. Ruelle, L. Delaby, M. Wallace and L. Shalloo (2015) Development and evaluation of the pasture base herd dynamic milk (PBHDM) model for dairy systems (Submitted to European Journal of Agronomy)

E. Ruelle, L. Shalloo, M. Wallace and L. Delaby (2015) Utilisation of the pasture base herd dynamic milk (PBHDM) model to predict the most financial viable grazing system in a post quotas environment. (Submitted to Journal of Dairy Science)

Savietto, D., Berry, D.P. and Friggens, N.C. (2014). Towards an improved estimation of the biological components of residual feed intake in growing cattle. Journal of Animal Science 2014,92:467-476

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