Transition cow management and cattle fertility

Professor Mark A. Crowe provides an overview of current research activities in relation to dairy cattle yield, productivity and fertility at UCD School of Veterinary Medicine

Mark A. Crowe
Professor of Animal Husbandry and Reproduction, School of Veterinary Medicine, UCD

Dairy cattle yield, productivity and fertility have increased since 2000. Current research activities revolve around:

1. Development of new phenotypic markers that are easily measured for a number of traits that are traditionally difficult to measure to aid in genetic selection programmes; and,
2. Development of early and accurate biomarkers of pregnancy status in either milk or blood.

Two significant research grants have enabled this research. These include an EU-funded grant called 'Genotype and the Environment (GplusE www.gpluse.eu)', and an SFI-funded grant on the 'Development of rapid biomarkers for early pregnancy state in dairy cows'.

The results obtained in GplusE will help dairy producers move to more sustainable practices. Our results show that one can detect cows with imbalanced energy status by the measurement of a number of biomarkers in milk. These will enable animal breeders to improve the selection of resilient, yet highly productive animals. They will also help farmers, veterinarians and Milk Recording Organisations (MROs) to manage dairy herds better, via individual monitoring of the health and welfare of the animals.

KEY RESULTS

An innovative research population obtained from research herds based in five countries provided the phenotypic variability to develop novel approaches linking milk composition-based biomarkers to production efficiency, health, metabolic status, fertility, environmental footprint and animal welfare state. Some key results were:

- Milk Mid-infra Red spectra can be used for a cheap, easy-to-implement and accurate prediction of the metabolic status of dairy cows: models have been constructed that can evaluate whether a cow is metabolically imbalanced with a global accuracy of 87 per cent (Tedde *et al*. 2021a, b).
- Milk MIR spectra might also be used for predicting many other innovative phenotypes (e.g., GplusE added knowledge on the prediction of Nitrogen efficiency of dairy cows; Grelet *et al*., 2020).
- The combined measurements of BHB (Beta-Hydroxy-Butyrate), NEFA (Non-esterified Fatty Acids) and IGF-I allows determination of whether the energy metabolism of an animal is imbalanced (Foldager *et al* 2020
- Measurements in milk can predict metabolic status with a fair accuracy. MIR spectra and measurements of metabolites and enzymes work fine, IgG glycans had insufficient accuracy (De Koster et al., 2019).

The results from the research population were used to obtain novel results in a larger population of MIR phenotypes and genotyped commercial cows; a few highlights:

- Targeted combination of estimated breeding values for lower accuracy MIR-based biomarkers increased their usefulness in genetic evaluation of dairy cattle for robustness (Krogh*et al*., 2020).
- Genome wide association studies may help in selection for improved resilience of dairy cattle to heat stress, association with calving interval and metabolic clusters (Atashi *et al* 2020a, b).

The project also studied relationships between some molecular phenotypes for key physiological traits:

- RNA sequencing data were obtained from the whole blood and liver of genotyped cows with extensive phenotype data available. These have identified gene pathways linking metabolic status with fertility and mastitis, providing new evidence to understand the relationships between immune status and health in postpartum dairy cows (Marchitelli *et al*. 2021; Wathes *et al* 2021).

GplusE-developed biomarkers worked not only in breeding; using the same innovative phenotypes, they contributed to advances in management:

- An HACCP approach for farm level management of critical negative energy balance has been developed: 11 risk factors and seven critical control points have been identified as the most important ones. Benefits from using milk MIR prediction of physiologically imbalanced cows in the approach have been evaluated by on-farm trials and by economic analyses.

Work in early pregnancy diagnostics has identified novel methods for detection of early pregnancy status by high resolution ultrasonography (Scully *et al*., 2014) and novel gene expression characterisation (Malo-Estape *et al*., in preparation).

REFERENCES

- Atashi H, Salavati M, De Koster J, Crowe MA, Opsomer G, Hostens M, The GplusE Consortium. A Genome-Wide Association Study for Calving Interval in Holstein Dairy Cows Using Weighted Single-Step Genomic BLUP Approach. Animals (Basel). 2020b Mar 17;10(3):500. doi: 10.3390/ani10030500. PMID: 32192064; PMCID:

PMC7143202.
- Atashi H, Salavati M, De Koster J, Crowe MA, Opsomer G; GplusE consortium, Hostens M. Genome-wide association for metabolic clusters in early-lactation Holstein dairy cows. J Dairy Sci. 2020a Jul;103(7):6392-6406. doi: 10.3168/jds.2019-17369. Epub 2020 Apr 22. PMID: 32331880.
- De Koster J, Salavati M, Grelet C, Crowe MA, Matthews E, O'Flaherty R, Opsomer G, Foldager L; GplusE, Hostens M. Prediction of metabolic clusters in early-lactation dairy cows using models based on milk biomarkers. J Dairy Sci. 2019 Mar;102(3):2631-2644. doi: 10.3168/jds.2018-15533. Epub 2019 Jan 26. Erratum in: J Dairy Sci. 2019 Apr;102(4):3778. PMID: 30692010.
- Malo-Estepa I, Johnston D, Diskin M, Crowe MA. High accuracy early pregnancy detection in cattle through gene expression in whole blood. In preparation.
- Foldager L, Gaillard C, Sorensen MT, Larsen T, Matthews E, O'Flaherty R, Carter F, Crowe MA, Grelet C, Salavati M, Hostens M, Ingvartsen KL, Krogh MA; GplusE Consortium. Predicting physiological imbalance in Holstein dairy cows by three different sets of milk biomarkers. Prev Vet Med. 2020 Jun;179:105006. doi: 10.1016/j.prevetmed.2020.105006. Epub 2020 Apr 21. PMID: 32361640.
- Grelet C, Froidmont E, Foldager L, Salavati M, Hostens M, Ferris CP, Ingvartsen KL, Crowe MA, Sorensen MT, Fernandez Pierna JA, Vanlierde A, Gengler N; GplusE Consortium, Dehareng F. Potential of milk mid-infrared spectra to predict nitrogen use efficiency of individual dairy cows in early lactation. J Dairy Sci. 2020 May;103(5):4435-4445. doi: 10.3168/jds.2019-17910. Epub 2020 Mar 5. PMID: 32147266.
- Krogh MA, Hostens M, Salavati M, Grelet C, Sorensen MT, Wathes DC, Ferris CP, Marchitelli C, Signorelli F, Napolitano F, Becker F, Larsen T, Matthews E, Carter F, Vanlierde A, Opsomer G, Gengler N, Dehareng F, Crowe MA, Ingvartsen KL, Foldager L. Between- and within-herd variation in blood and milk biomarkers in Holstein cows in early lactation. Animal. 2020 May;14(5):1067-1075. doi: 10.1017/S1751731119002659. Epub 2019 Nov 7. PMID: 31694730.
- Marchitelli C, Palma-Vera S, Wylie A, Takeda H, Tang L, Crowe MA, Wathes DC; GplusE consortium. Global transcriptomic profiles of circulating leucocytes in early lactation cows with clinical or subclinical mastitis. Mol Biol Rep. 2021 May;48(5):4611-4623. doi: 10.1007/s11033-021-06494-8. Epub 2021 Jun 19. PMID: 34146201.
- Scully S, Butler ST, Kelly AK, Evans AC, Lonergan P, Crowe MA. Early pregnancy diagnosis on days 18 to 21 post insemination using high-resolution imaging in lactating dairy cows. J Dairy Sci. 2014;97(6):3542-57. doi: 10.3168/jds.2013-7518. Epub 2014 Mar 20. PMID: 24657084.
- Tedde A, Grelet C, Ho PN, Pryce JE, Hailemariam D, Wang Z, Plastow G, Gengler N, Froidmont E, Dehareng F, Bertozzi C, Crowe MA, Soyeurt H, On Behalf Of The GplusE Consortium. Multiple Country Approach to Improve the Test-Day Prediction of Dairy Cows' Dry Matter Intake. Animals (Basel). 2021a May 4;11(5):1316. doi: 10.3390/ani11051316. PMID: 34064417; PMCID: PMC8147833.
- Tedde A, Grelet C, Ho PN, Pryce JE, Hailemariam D, Wang Z, Plastow G, Gengler N, Brostaux Y, Froidmont E, Dehareng F, Bertozzi C, Crowe MA, Dufrasne I, Soyeurt H, GplusE Consortium Group. Validation of Dairy Cow Bodyweight Prediction Using Traits Easily Recorded by Dairy Herd Improvement Organizations and Its Potential Improvement Using Feature Selection Algorithms. Animals (Basel). 2021b Apr 30;11(5):1288. doi: 10.3390/ani11051288. PMID: 33946238; PMCID: PMC8145206.
- Wathes DC, Cheng Z, Salavati M, Buggiotti L, Takeda H, Tang L, Becker F, Ingvartsen KI, Ferris C, Hostens M, Crowe MA; GplusE Consortium. Relationships between metabolic profiles and gene expression in liver and leukocytes of dairy cows in early lactation. J Dairy Sci. 2021 Mar;104(3):3596-3616. doi: 10.3168/jds.2020-19165. Epub 2021 Jan 15. Erratum in: J Dairy Sci. 2021 May;104(5):6327. PMID: 33455774.