Biomarkers to improve cow longevity

The Challenge

Dairy cows start producing milk when they first calve at approximately two years of age. Up until that time they only incur expense to the farmer. After calving, cows must remain in the herd for another two to three years to produce enough milk to allow the farmer recover this expense and start making profit. However, as intensity of milk production increases, more and more cows tend to leave the herd earlier due to disease or poor fertility. Indeed, more than 20% of dairy heifers in the UK currently fail to reach their first calving and onset of milking, whilst many more are culled before achieving their full production potential. This means other, less profitable cows have to remain in the herd longer to ensure whole herd output is maintained.

The Research

As most of the traits determining the length of a cow's productive life are manifested during her mature years, an early-life predictor of the cow's future would be an extremely useful tool for on-farm management practices and selective breeding programmes.

Our research evaluated early-life biomarkers as predictors of cow longevity. We examined: (i) the length of telomeres, which are small structures capping the chromosome ends in animal cells and are known to be associated with aging, and (ii) the profiles of blood circulating microRNAs, which are molecules associated with various important biological functions.

The length of telomeres from white blood cells and the expression of 300 microRNAs in plasma were assessed in young female calves born into the study before 2016. These measurements were then associated with mature-life performance and longevity of these animals

The Results

We conducted the world's largest telomere genetic study, in a species other than human, and found bovine telomere length at birth to be a heritable trait with a significant association with survival, length of productive life and future health status of the animal.

Results also showed certain plasma microRNAs being associated with animal traits such as milk somatic cell count (a mastitis indicator), fertility, lameness, and blood metabolites linked with body energy balance and metabolic stress. All these traits play a critical role in involuntary culling decisions that affect the length of productive life of cows.

The Impact

Both telomere length and circulating microRNA levels measured in early life may provide useful selection biomarkers for dairy cows to help improve longevity, health, welfare and production performance. These early-life biomarkers can feature in both farm management practices and genetic improvement programmes.

Research activities in the above areas of study have enhanced our links with possible collaborators nationally and internationally, thereby creating new research opportunities. Future activities will further utilise and benefit from the SRUC capacity in the Langhill study, as well as the SRUC biomarkers lab.

The Future

The Langhill study generates invaluable data that have made this type of research possible. Detailed phenotypic and genomic information being systematically recorded will be used in future studies aiming to dissect the genomic architecture of predictive biomarkers, characterise their profiles and function, and unravel the regulatory mechanisms linking these biomarkers to animal longevity and mature-life performance. Future research will also determine the optimal way to incorporate the biomarkers in selective breeding programmes aiming to enhance dairy efficiency.
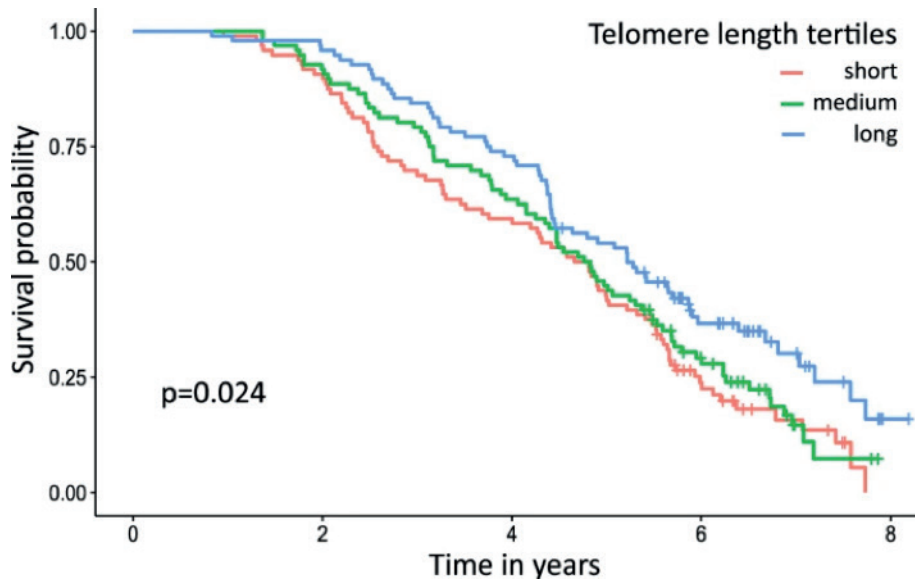
Figure 1. Longer bovine telomeres increase the probability of cow survival
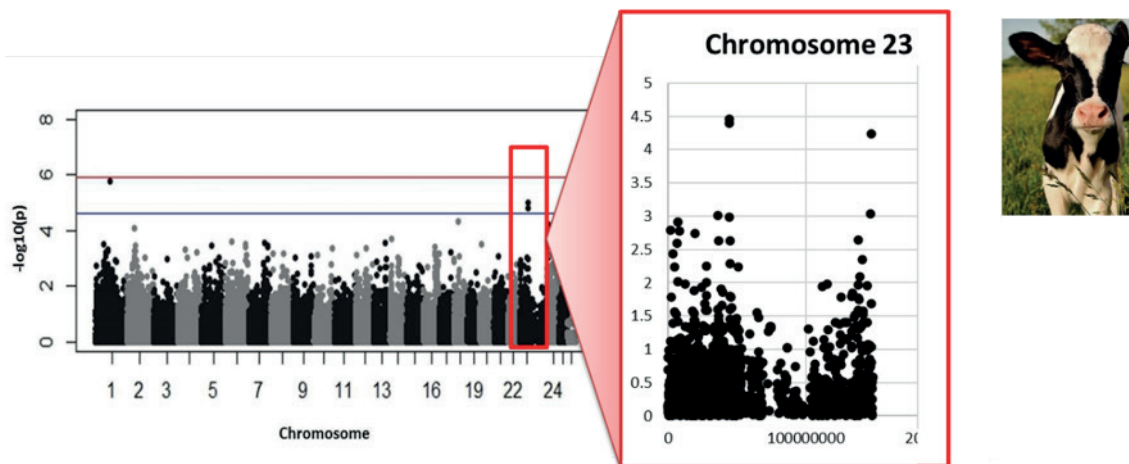(Seeker et al, 2018a)

Figure 2. There is heritable genetic variation in bovine telomere length at birth and there are genomic regions affecting this trait; therefore, telomere length may increase with selective breeding
(Ilska et al, 2019)

Additional Information:

Publications:

Ilska JJ, A Psifidi, LA Seeker, RV Wilbourn, SL Underwood, J Fairlie, B Whitelaw, DH Nussey, MP Coffey and G Banos. 2019. "The genetic architecture of bovine telomere length in early-life and association with animal fitness" Frontiers in Genetics 10:1048. doi: 10.3389/fgene.2019.01048.

Ioannidis J, E Sánchez-Molano, A Psifidi, FX Donadeu and G Banos. 2018. "Association of plasma microRNA expression with age, genetic background and functional traits in dairy cattle" Scientific Reports 8:12955 doi: 10.1038/s41598-018-31099-w.

Seeker LA, JJ Ilska, A Psifidi, RV Wilbourn, SL Underwood, J Fairlie, R Holland, H Froy, E Salvo-Chirnside, A Bagnall, B Whitelaw, MP Coffey, DH Nussey and G Banos. 2018a. "Bovine telomere dynamics and the association between telomere length and productive lifespan" Scientific Reports 8:12748 doi:10.1038/s41598-018-31185-z.

Seeker LA, JJ Ilska, A Psifidi, RV Wilbourn, SL Underwood, J Fairlie, R Holland, H Froy, A Bagnall, B Whitelaw, MP Coffey, DH Nussey and G Banos. 2018b. "Longitudinal changes in telomere length and associated genetic parameters in dairy cattle analysed using random regression models" PLoS ONE 13(2): e0192864 doi.org/10.1371/journal.pone.0192864.

Seeker LA, R Holland, S Underwood, J Fairlie, A Psifidi, JJ Ilska, A Bagnall, B Whitelaw, MP Coffey, G Banos and DH Nussey. 2016 "Method specific calibration corrects for DNA extraction method effects on relative telomere length measurements by quantitative PCR" PLoS ONE 11(10): e0164046 DOI: 101371/journalpone0164046.