

Animal Research Programme – Genetic Improvement of Animals

RMIS No: 6162

Title

Whole Genome Selection through Genome Wide Imputation in Beef Cattle

Abstract

This research program will deliver genomic technology to Canada's beef industry and enable it to substantially increase rates of genetic improvement, a key determinant of producer profitability and product quality. Traits targeted are those that are very difficult to improve using conventional means. Genotypes from a wide range of beef and dairy breeds will be used to develop accurate and robust genomic prediction equations that are applicable to Canada's cattle populations. The project involves extensive collaboration with scientists (and data) from the US, Australia, Britain, Ireland and New Zealand, as well as leading Canadian seedstock organisations.

The program consists of three interconnected research streams: 1) the social determinants of benefits and costs of using genomic technologies in livestock improvement will be identified; 2) procedures will be developed to provide low-cost but accurate genome-wide selection (GWS) methodologies; 3) research will be undertaken to allow GWS to be used in Canadian herds for particularly difficult yet valuable traits, supported by establishment of infrastructure and other requirements that facilitate industry utilisation of GWS.

The first research stream (Activity 2) will address the desirability of using genomic technologies from the perspectives of all stakeholders, taking account of potential impact on livestock product attributes (e.g. food safety and quality), using national and specifically-targeted surveys in combination with econometric modelling. The remaining components will require the genotyping of a large number of animals to attain acceptable levels of reliability of genetic evaluations. This can only be achieved through international collaboration, especially for important hard-to-measure traits like feed efficiency and reproduction. Theoretical and methodological developments are necessary in order to develop affordable yet accurate DNA assays. In particular, there is a need to discover causal mutations associated with economically important traits and possibly to design breed- or population-specific assays using knowledge of the haplotype structure within and across breeds. Breed structures will be characterised and key ancestors at the top of each breeding pyramid identified for genome sequencing (Activity 3). Activity 4 will involve moving down the population pyramid with decreasing genotype density (770K, 50K and low density SNPs) but increasing numbers of animals, so that in Activity 5, imputation methods can be developed and used to derive the haplotype structure of commercial herds at the bottom of each pyramid. This strategy will then be applied to the targeted areas of feed efficiency and resource use (Activity 6) and reproduction and longevity (Activity 7) in Canadian herds. Reproduction and longevity are low heritability traits, so the GWS studies will be augmented by functional genomic and candidate gene investigations to increase the likelihood of finding important causative mutations. Activity 8 is directed at transferring the technology to industry to ensure economic benefits for Canada.

Canadian researchers are at the forefront of developing the application of genomic selection to boost rates of genetic gain. Canada was directly involved in both sequencing of the bovine genome and development of the BovineSNP50 chip through support from Genome Canada, the Alberta Bovine Genomics Program (now Livestock Gentec), Industry and Federal and Provincial Governments. It is critical that the country benefits from these investments in the basic science by developing applications that are highly effective and affordable for breeders of farm animals.

Associated benefits from this research include the identification of causal mutations and an understanding of how other forms of genetic variation such as InDels, copy number variants, and non-additive variation can be used for genetic improvement in cattle. Thus the project aims to deliver immediate benefits for breeders and also lay the foundation for the next generation of technologies, including improved capability for ensuring the environmental sustainability of beef and dairy cattle production. The net present value of this research to Canada over ten years is estimated to be well in excess of \$300m.

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Start Date: 1 July 2011
Expected Finish date: 1 September 2014