Breeding livestock for climate resilience: the capacity to maintain production and fitness in a changing climate

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The number and strength of extreme weather patterns (both hot as well as cold spells) are expected to increase through climate change, posing a considerable threat for livestock species. Despite the fact that most livestock species in Canada are housed indoors, heat, dry spells, and rapidly fluctuating extreme temperatures pose significant challenges to Canadian producers. In addition, climate change may alter animal food availability and quality, and these changes will ultimately require animals that are more feed efficient. Temperature stress increases vulnerability to disease and reduces fertility and production. Genetic variants associated with heat tolerance have been identified in dairy cattle, however little is known about the genetic architecture of resilience to extreme temperature changes. The challenge is to breed animals that can produce healthy, viable offspring and hold production levels constant, even under heat or cold stress. In addition, methane produced by ruminants contributes to worsening the effects of climate change and therefore, has to be reduced. Considering that, more research is needed to identify genetic variants with an influence on heat/cold tolerance, feed efficiency and methane emissions in livestock species while maintaining or increasing levels of production and reproduction.

The main goal of this activity is to identify genes, as well as structural and regulatory regions of the genome of livestock species (with a focus on ruminant species such as beef and dairy cattle, sheep and goats), that are involved in adapting to different stressors triggered through climate change for allowing efficient selection for robust livestock tolerant to extreme temperatures and more productively efficient.

The specific research activities are:

1. Survey past and current research efforts and existing datasets

Past and current environmental data from local weather stations (e.g. in Elora Research Stations) and other research stations across Canada will be retrieved and curated to ensure quality. The Centre for Genetic Improvement of Livestock (CGIL, University of Guelph) has been involved in various international research projects to mitigate the effects of climate change and therefore, the data generated from these collaborations will be added to the current database. This dataset includes genotypes and phenotypes from a variety of cattle, sheep and goat breeds well adapted to specific climate conditions such as cold or hot weather, high altitudes and adverse wind conditions, etc.

2. Combine performance data and define indicators of temperature stress

Through combining climate information and livestock performance data from ruminants (dairy and beef cattle, goat, sheep), performance traits (e.g. milk production, reproduction and fertility, health and growth) and indicators of temperature stress will be defined. Various phenotypes have been (or will be) collected to predict resilience in animals such as performance and reproduction traits, immune response, milk composition predicted from mid-infrared (MIR) spectra analysis (focus on milk fat), body condition score measured over time, hair density and structure, skin thickness, blood and feces parameters, coat color, activity and social behavior, rectal and intra-vaginal temperature, ear temperature and temperature of other body extremities, hair and feces cortisol and heart rate.

These datasets will be converted into a common format and recorded in the Animal Biosciences Database being developed as part of CFREF.

3. Carry out genetic and genome-wide association analyses
Genetic and genomic studies on identified resilience traits, immune studies, and microbiome profile and biomarkers (identified in Activity 2.A. and through other studies being conducted within CGIL) will be combined and analysed to investigate their genetic background and relationships with other economically important traits.

4. Evaluate potential candidate genes' response to temperature stress
The genomic regions associated with heat/cold stress identified in step 3 will be validated within other projects conducted by our research group through larger association studies, functional tests of target SNPs at promotor regions, analyses of 3' untranslated regions (UTR), or analyses of coding sequences.

5. Predict molecular breeding values for adaptation traits
After describing the genetic background of the identified adaptation traits, genomic breeding values will be generated to allow for selection to these traits and consequently make genetic progress in Canadian herds.