Project No:
Internal Use

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BCRC
BEEF CATTLE RESEARCH COUNCIL

PROJECT PROPOSAL

Please ensure you have read and followed the Instructions and Guidelines document prior to submitting a Project Proposal.

Applicant Information

Project Leader: John Basarab / Changxi Li

Position: Research Scientist

Organization: Alberta Agriculture and Forestry /Agriculture and Agri-Food Canada (AAFC)

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Co-Investigator(s) Name(s) & Organization(s):

Carolyn Fitzsimmons, AAFC
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Hushton Block, AAFC
Mohammad Khakbazan, AAFC
John Crowley, CBBC and LG
David Benfield, Growsafe System Ltd.

Project Information

Project Title: *(25 words maximum)*

Genetic analyses of feed intake, feed efficiency, female fertility, and cow lifetime productivity in beef cattle raised under two environments

Start Date: April 1, 2018 End Date: March 31, 2023

BCRC Priority Outcome(s) Addressed in the Proposal: *BCRC target outcomes outlined in the call for LOI's doccument; Be as specific as possible.*

Feed Grains and Feed efficiency:

Quantify the genetic relationships between feed intake and efficiency in cow-calf and feedlot production, and their relationships with other economically relevant beef production traits (longevity, fertility, weaning weight, wintering costs, carcass weight, yield and quality grades, tenderness, etc.).

Project Summary

400 words maximum. Summarize the project purpose, objectives and deliverables in lay terms, and state how the research addresses the above priority area(s). Avoid copying detailed information from other sections of this document.

Feed efficiency, feed intake, production performance and fertility are major determinants of sustainable beef production. Understanding genetic correlations among these traits is crucial for optimizing multiple trait selection indices that improve sustainability. Genetic correlations of feed intake, feed efficiency with growth and carcass traits are well documented (Nkrumah et al. 2007; Arthur and Herd 2012; Mao et al. 2013). However, genetic correlations of heifer and cow feed intake and efficiency with fertility traits, longevity and lifetime productivity (LTP) are limited and inconsistent. This proposal plans to build on historical feed intake, growth, cow reproductive and 50k SNP genotyping data collected at the Lacombe Research and Development Centre (LRC) and Roy Berg Kinsella Research Station (KIN) over the last 11 and 4 years, respectively. Data were collected under two winter feeding treatments: LRC-CONFINED, fed silage in confinement; LRC-PASTURE, grazed stockpiled forage on pasture; KIN-CONFINED-fed silage in confinement; KIN-PASTURE, fed stored forage on rangeland. These winter feeding treatments will be continued over the 5 year project. LRC will test 80 heifers/yr and 40 cows/yr for feed intake, and add 190 cow matings/yr under CONFINED and 112 cow matings/yr under PASTURE winter feeding treatments. When summed with historical data, LRC will have 2780 cow matings under CONFINED and 996 cow matings under PASTURE winter feeding treatments. KIN will test 120 heifers/yr and 40 cows/yr for feed intake, and add 40 cow matings/yr under CONFINED and 150 cow matings/yr under PASTURE winter feeding treatments. When summed with historical data, KIN will have 322 cow matings under CONFINED and 1200 cow matings under PASTURE winter feeding treatments. Thus in total, there will be 2697 heifers and 689 cows with feed intake, feed efficiency, and reproductive data, and 3102 cow mating opportunities under CONFINED (higher inputs) and 2196 under PASTURE winter feeding treatments. Data will be used to quantify phenotypic and genetic correlations of feed intake and feed efficiency with female fertility, longevity and lifetime productivity. Additive and non-additive (heterozygosity) effects will be assessed under two winter feeding conditions, as recent results have shown that females with increased heterozygosity had improved fertility, longevity and lifetime productivity, and this response was partially dependent on winter feeding management. These findings will be confirmed on 2000 industry heifers using Growsafe's marketing approach to on-farm phenotyping such that a heifer value index will be calculated for each heifer for improved feed efficiency and reproductive performance.

Project Description

Maximum of 4 pages.

Please address all of the following items in the order specified.

1) *Purpose & Objectives*
2) *Background & Brief Literature Review*
3) *Experimental Design, Methodology, and Analysis*

1). Purpose and Objectives:

Selection for improved feed efficiency while maintaining or improving heifer or cow reproductive performance will significantly reduce the production cost while reducing the carbon footprint of beef production. To achieve this breeding goal, a multiple trait selection index or heifer value index must be used to make selection decisions. In addition, assessment of effects of retained heterozygosity (non-additive genetic effect) on heifers and cows performance will also help us select and produce a cow herd with optimal hybrid vigor to improve reproductive performance. Therefore, the objectives of this study are to : (1). Estimate genetic and phenotypic correlations of dry matter intake (DMI) and feed efficiency with heifer fertility, longevity and lifetime productivity (LTP) of cows reared under two winter feeding systems: Higher Inputs vs. Lower Inputs. (2). Determine relationships of mature cow DMI per weight of calf weaned over 3 and 6 calvings with heifer performance. (3). Predict heifer fertility and cow LTP using additive, non-additive and environmental effects. (4). Quantify the economic value differences among heifers using feed intake, fertility, LTP and longevity. (5). Phenotype 2000 commercial heifers for feed intake and efficiency using Growsafe's marketing approach and create value indices for these heifers.

2). Background and Brief Literature Review:

In western Canada, the beef cow herds at the Lacombe Research and Development Centre (LRC) and the Roy Berg Kinsella Research Station (KIN), University of Alberta support a wide range of beef cattle studies. The LRC herd consists of approximately 400 spring calving crossbred cows predominated by Aberdeen Angus-Hereford, Red Angus-Charolais, and more recently by Angus-Simmental crosses, which are common crossbreds in western Canada (Alberta Cow-Calf Audit, 2001). The cows are managed under two winter feeding treatments (2007-2017): 1) CONFINED [Higher Inputs], where cows are fed forage diets (e.g., 30% straw:70% hay, barley silage or triticale silage) plus protein-trace mineral supplement (TDN=61%; NEm=1.34 Mcal/kg) from November to February in pens equipped with the Growsafe System (GrowSafe Systems Ltd., Airdrie, Canada), or on confined wintering sites where they received barley silage plus supplement until returned to pasture in May-June, and; 2) PASTURE [lower inputs], where cows grazed barley, triticale, corn or oat swaths (TDN=57-68%; NEm=1.21-1.57 Mcal/kg) from November to March, then are placed in confined wintering site with all other cows prior to calving where they received barley silage until placed back on pasture in May-June. Effects of swath grazing treatments on animal performance can be determined and are described in Baron el al. (2014, 2016). Breeding season for replacement heifers starts the first week in June and lasts 40-45 days, while the cows' breeding season extends from early June to late July (60-65 days). Bulls included registered Aberdeen Angus, RedAngus and Simmental, and are selected based on ADG, 365-d yearling weight, temperament, conformation, calving ease and breeding soundness evaluation. Calves are born from the first week in March to mid-May of each year.

Project Description (cont'd)

At weaning in October, all calves are weighed and tagged with a half-duplex radio frequency transponder button (Allflex USA, Inc., Dallas/Fort Worth Airport, TX) in the right ear. The KIN herds consist of 420 beef composite (KC), 200 Aberdeen Angus, and 125 Charolais cows. For the KC herd, heifer average breed composition is 56.9% Angus, 18.6% Gelbvieh, 9.8% Hereford, 6.6% Simmental, 5.6% Charolais and 2.5% Limousin. Over the past three years (2015-17), cows were managed under two winter feeding treatments: 1) CONFINED [higher inputs], where cows are fed barley silage plus rumensin-trace mineral supplement (TDN=61%; NEm=1.34 Mcal/kg) from November to February in pens equipped with the Growsafe System, and; 2) PASTURE [lower inputs], where cows are fed lower quality hay or haylage on rangeland (TDN=53%; NEm=1.07 Mcal/kg) to maintain body condition score during the 2nd-3rd trimester of pregnancy and then supplemented with oats to increase energy of the diet 60 days before calving and post-calving until placed back on pasture in May-June. Breeding season for replacement heifers extends from mid-June to early-August (~50 days) and from early-July to early-September for the KC cows (~60 days). Bulls used on KC cows were KC and Beefbooster M4 hybrids used in multi-sire mating groups on pasture. Selection of bulls was and will be based on ADG, 365-d yearling weight, temperament, conformation, calving ease and breeding soundness evaluation. Calves were born from late-March to June. All calves are raised by their dams until weaning which occurred from late October to end of November. Each year in both herds all calves are DNA sampled (blood or ear tissue sampled using TypiFix-TM) and then genotyped on the Illumina BovineSNP50K Bead Chip. Post-weaning, at 8-11 months of age, all KIN calves and LRC heifers are tested for feed intake and efficiency using the GrowSafe system and following procedures described by (Basarab et al 2007, 2011, 2013; Mao et al. 2013). Records by parity (1-11) are available for calf birth date and weight, calving ease and condition, wean date and weight, calf pre- and post-weaning ADG, cow weights and backfat and/or rump fat thickness (ultrasound) at pre-breeding, pregnancy check and pre-calving, age at first calving, calving interval, culling reason and date, and genomic breed composition (Appendix A). In this project, daily body weight will also be recorded using Growsafe Beef while cattle are in drylot or on pasture. Climatic data will be recorded by weather stations within 1-2 km of the cattle and by smaller remote portable weather station placed in drylot pens and on pasture. These data, along with ultrasound fatness measurements, will be used to estimate dry matter intake of cattle while grazing using procedures described by NRC (2016). To date, 850 LRC and 847 KC heifers had been measured for feed intake and efficiency. Of these 167 and 122 had been re-tested for feed efficiency as mature cows at LRC and KIN, respectively. In addition, 1830 LRC cow matings had occurred under CONFINED, 436 LRC cow matings under PASTURE, 122 KC cow matings under CONFINED and 450 KC cow matings under PASTURE treatments (Appendix A).

Feed intake and reproductive data of cows are difficult to measure, therefore, investigation on impact of selection for feed efficiency on cow reproductive traits or their genetic correlations are limited and the results are inconsistent. For example, Johnston et al. (2009) detected a negative genetic correlation (-0.60) of residual feed intake (RFI) with the age of first-observed corpus luteum (CL) while the feed intake and CL had a low correlation (-0.02) in Brahman cattle. However, in the Tropical Composite herd the

Project Description (cont'd)

genetic correlation of both feed intake and RFI with CL were low (<0.10) (Johnston et al. 2009). In the case of mixed breeds of Aberdeen Angus (AN), Charolais (CH), Hereford, Limousin (LI), and Simmental, Crowley et al. (2011) observed a negative genetic correlation of feed intake, and RFI with age of first calving (-0.23 and -0.29), suggesting that selection for improved efficiency may delay age at first calving. Moreover, it still remains unclear how selection on feed intake and feed efficiency will influence other cow reproductive traits such as longevity and life-time productivity and how female retained heterozygosity are related to their reproductive performance under different winter feeding systems. Therefore, we propose to utilize feed intake and reproductive data from the LRC and KIN cow herds to conduct a more comprehensive genetic analysis of feed intake, feed efficiency, female fertility, and cow lifetime productivity in beef cattle.

3). Experimental Design, Methodology and Analyses:

3.1. Animal population and phenotype data collection: The LRC and KIN KC beef cattle herds will be used in this study. In addition to the cow data already collected, this project proposes to add 400 heifers (80/yr) and 200 cows (40/yr) tested for feed intake, and 950 cow matings under CONFINED treatment (190/yr) and 560 under PASTURE treatment (112/yr) at LRC between 2018 and 2022. At KIN, 600 KC heifers (120/yr) and 200 KC cows (40/yr) will be tested for feed intake, and 200 KC cow matings under CONFINED treatment (40/yr) and 750 KC cows under PASTURE (150/yr) treatment will be added (Appendix A). Collection of reproductive data on the cows/heifers will continue, which will provide a data set of 2697 heifers and 689 cows with feed intake, feed efficiency and reproductive traits for estimation of genetic and phenotype correlations with female fertility, longevity and lifetime productivity. In addition there will be 3102 cow mating opportunities under CONFINED (higher inputs) and 2196 under PASTURE winter feeding treatments to assess additive and non-additive effects under the two winter feeding conditions (Appendix A).

3.2. Genotyping of animals: All heifers used in the past years were genotyped on the bovine 50K SNPs (N=1697). Under the proposed project, all new heifers (N=200/yr) will be genotyped on the GGP-LD SNP panel (36K SNPs) and sires will be genotyped on the bovine 50K SNPs for parentage analyses. In addition, mature cows in both the herds will be genotyped on the GGP-LD SNP panel (200 cows/yr). Genotypes of the GGP-LD SNP panel will be imputed to the 50K SNPs using FImpute software based on a larger Canadian beef cattle 50K SNP data set (N=11,450).

3.3. Statistical data analyses:

3.3.1. Feed intake, feed efficiency and reproductive data of cows from LRC and KIN herds will be consolidated, and fertility traits will be standardized. Longevity is a complex trait that has been defined in multiple ways in cattle such as length of life from first calving to disposal, age at disposal, survivability and stayability (Tanida et al. 1998; Ducrocq 2002; Hudson and Van Vleck, 1981). Life time productivity (LTP) of cows will be defined as total calf weight weaned in a life or within 4 years of breeding depending on data structure. Realized longevity and LTP of cows (i.e. total calf weight weaned) will be calculated based on uncensored records (cows were culled). Predicted longevity and LTP for younger cows or live cows will be obtained based on uncensored and censored records (cows are alive) using various statistical models including a Weibull proportional

Project Description (cont'd)

hazard model (Cox, 1972; Durcocq 2002) in collaboration with a project funded by AF (PI Basarab, 2017F103R).

3.3.2. Phenotypic and genetic variances and covariances between DMI, feed efficiency measures, reproductive traits including longevity and LPT will be estimated using a bivariate animal model as implemented in ASReml 4.0 (Gilmour et al., 2015). Fixed effects including winter feeding systems will be properly determined and included in the model and their effects will be estimated. Parentage will be determined based on the SNPs and will be used to calculate the animal additive relationship matrix for ASReml.

3.3.3. Determination of relationships of mature cow DMI per weight of calf weaned over 3 and 6 calvings with heifer performance: Relationship of mature cow DMI per weight of calf weaned over 3 and 6 calvings with heifer performance including DMI, feed efficiency, body weight and growth will be estimated using a bivariate animal model as in ASReml 4.0 (Gilmour et al., 2015) by treating DMI and feed efficiency measured at the heifer and at the cow stage as two different traits.

3.3.4 Prediction of heifer fertility and cow LTP using additive, non-additive (genomic retained heterozygosity (RH) and heterosis) and environmental effects: GWAS (genome-wide association) using regression and Bayesian methods will be carried out to identify SNPs marker associated with the cow feed intake, feed efficiency, female fertility, and LTP (additive effect) as in a previous study (Chen et al. 2015). Animal genomic breed composition that will be determined based on SNP genotypes using ADMIXTURE software (VanRaden and Cooper. 2015; Huang et al., 2014). Then retained heterozygosity (RH or hybrid vigor score) for each individual will be calculated as RH=1-(sum of squares for each genomic breed fraction). Additive, non-additive (RH), and environmental effects on fertility and LTP will be evaluated by regression. Impacts of selection on feed intake, efficiency as well as RH on cow fertility, longevity and LTP will be examined for swath grazing and confined feeding systems.

3.3.5 Quantify the economic value differences among heifers using feed intake, fertility, LTP and longevity: Economic value differences among heifers and cows of different feed intake, fertility, LTP and longevity will be quantified using both current market values and simulation under various scenarios including salvage values of culled cows. Consequently, a multiple trait index or a heifer value index including feed intake, feed efficiency, cow fertility, longevity, LTP will be constructed based on economic weight of each trait and their variance/effect and correlations to maximize economic returns.

3.4. On farm phenotyping for feed intake and efficiency using Growsafe's marketing approach (measure 2000 heifers for creating value indices) will be conducted on site (400 heifers/yr), and the heifers will be genotyped on SNP panel of GGP-LD (36K SNPs). Breed composition and RH of the heifers will be predicted and calculated as described previous. Based on the SNP, RH, feed intake and other performance, a value index for each heifer will be calculated using the multiple trait index prediction model developed in the project. To ensure that we have adequate genetic materials for future DNA work, extra DNA samples will be collected on the industry heifers for further research and development.

Project Milestones

Ensure you have reviewed and understand this section of the Instructions and Guidelines document before completing.

Objective	Expected Outputs/Deliverables	Output Indicators	Fiscal Year (Apr 1 – Mar 31)
Estimation of genetic correlation of feed intake, feed efficiency and fertility related traits.	Genetic and phenotypic correlation coefficients between feed intake, feed efficiency and fertility related traits.	The genetic and phenotypic correlation coefficients are estimated and reported.	Start: April 1, 2018 End March 31, 2023
Relationships of mature cow DMI per weight of calf weaned with heifer performance.	Correlation coefficients of mature cow DMI per weight of calf weaned with various heifer performance traits.	The correlation coefficients of mature cow DMI per weight of calf weaned with heifer performance traits are estimated.	Start: April 1, 2019 End: March 31 2023
Prediction of heifer fertility and cow LTP using additive, non-additive and environmental effects.	SNP additive and non-additive (RH) and environmental effects on heifer fertility and cow LTP.	A prediction equation of heifer fertility and cow LTP using SNP additive, non-additive, environments is developed.	Start: April 1, 2019 End March 31, 2023
Economic value differences among heifers with different feed intake, fertility, RH, LTP and longevity.	Economic value increase or decrease per unit of feed intake, fertility, RH, LTP and longevity.	Multiple trait selection index or heifer value index is developed based on economic value and their correlations.	Start: April 1, 2019 End March 31, 2023
On farm phenotyping for feed intake and efficiency and prediction of heifer value index	2000 industry heifers measured using Growsafe's marketing approach. Multiple trait selection index or heifer value index calculated.	Multiple trait selection index or heifer value index of 2000 industry heifers are delivered.	Start: April 1, 2018 End: March 31, 2023
Interim project and final project reports	Interim project will detail progress of the project. Final project report will include major findings and lessons learned and future research directions.	Interim project and final project reports will be delivered to the funding agency and industry partners on time.	Start: April 1, 2018 End March 31, 2023

Related Research

Identify how this project builds on other research and/or how it is unique from other research that has been completed or is currently in progress:

This project builds on the Phenomic Gap (ALMA, PI Basarab, 2008F134R) and Canadian Cattle Genome Project (Genome Canada, PI Moore/Miller) that established databases with over 320 whole bovine sequence genomes, over 18,000 genotypes from seven beef breeds and three crossbred populations and close to 8,000 phenotypes for traits such as residual feed intake. As part of the larger international 1,000 Bull Genomes Project, we also have access to over 1000 legacy genomes, and have the capability to exploit whole genome sequences of 96 bulls, representing 19 U.S. cattle breeds just released to the public by USDA Agricultural Research Service. It is important to capitalize on these investments and the foundational resources available to begin mining for functional variants to develop the next generation of genomic marker panels for advancing the cattle industry and to develop new genomic tools for the Canadian beef industry. Towards this end, our Livestock Gentec team and Delta Genomics transitioned seven major Canadian beef breeds from microsatellite parentage to SNP parentage in 2013, and in 2017, Delta Genomics and the Livestock Gentec team released the second ever Canadian made genomic tool called "EnVigour HX" that provides SNP parentage, genomic breed composition, mate matching and genomic based-Hybrid Vigor Score for commercial cattle producers. Other projects which support these efforts are 1. gEPD for commercial cattle (Genome Alberta; PI Basarab; RES0028243), 2) Kinsella Feed Efficiency Breeding project (ALMA, BCRC; PI Plastow; 2013R027R), 3) Genetic diversity and heterosis in Canadian beef cattle (ALMA, PI Plastow); 4.) Beef cattle functional genomic prediction project (ALMA; PI. Li; 2014F047R); 5).Using residual feed intake to improve lifetime productivity of beef cows (ALMA; PI Basarab, 2011R006R); 6). Evaluating a new tool (GGP-F250) for improving accuracy of gEPDs for production efficiency in commercial beef cattle (AF, PI Basarab, 2017R034R); and 7).Optimize heterozygosity in crossbred beef cattle using genomic tools (AF, PI Basarab, 2017F103R). These latter two projects have been recommended to AF for funding, and a major objective of Project 7 is to determine number of SNPs required for developing a low cost panel that accurately predict genome-wide heterozygosity. In addition, Dr. Vern Baron's full BCRC proposal on winter swath grazing creates contrasting winter feeding environments (Confined vs. Swath grazing) at Lacombe for cost reduction, with recognition that winter grazing can be challenging for some cow biological types and cows with low hybrid vigor.

Communication and Technology Transfer Plan

Describe in three (3) sentences or less the potential benefit of this research to Canada's beef industry if the desired outcome is achieved:

This project will test 2000 commercial heifers for feed intake using Growsafe's Marketing Approach to on farm phenotyping, thus direct demonstration and deployment to beef producers will occur through Value ($) Indices for maternal traits including RFI, ADG and BW gEPDs, as well as for genomic tools like genomic breed composition, mate matching and Hybrid Vigor Score. Within this project, these Index dollar values and genomic tools will be deployed through Growsafe Systems Ltd.

If the desired outcome is achieved, what sector of the beef industry will benefit from this research (check all that apply)?					
Cow-calf	Backgrounding	Finishing	Packing	Retail	Other (specify)
✓	✓	✓	☐	☐	

If the desired outcome is achieved, briefly describe how you expect these research results could benefit the sector(s) you identified above by:	
What production cost will be reduced?	Cow-calf production cost including cow feeding cost, replacement heifer cost, cost of production will be reduced.
What product value attribute(s) will be improved?	Improved sustainability of beef production; lower carbon footprint; improved efficiency use of feed resources, improved animal welfare and improve profitability and competitiveness.
Indicate the benefits for public confidence, animal welfare, environmental impact and industry competitiveness.	Production of more efficient cows with improved performance will reduce production cost and carbon intensity. For example, the high RH heifers have a carbon intensity of weaned calf production that is 15-27% lower than low RH heifers. Incorporating these effects into a Value index for each heifer would improve the carbon intensity of beef production, improve animal welfare and resilience, and profitability.

What mechanisms have you identified as most appropriate to ensure transfer of the proposed research results and encourage industry uptake?

*In answering the above question, please address **all of the** following items:*

1) *What specific industry events do you intend to present these findings at?*
2) *What specific research events do you intend to present these findings at?*
3) *What industry magazines, newsletters or other popular press will you approach to circulate findings?*
4) *What scientific journal(s) do you intend to publish these findings in?*
5) *What other forms of communication will you use to disseminate findings? E.g.: video, webinar, interactive web-based decision tools*
6) *What industry groups will you approach to partner on the development or distribution of extension resources?*
7) *Where applicable, what commercialization efforts will be made?*
8) *Where applicable, what future research is required to move this activity closer to commercialization?*

Within this project we will deploy value indices through Growsafe Systems Ltd., to ensure direct deployment of technology to commercial cow-calf producers and key seedstock breeders. We will also collaborate with AAF, AAFC and ABP extension and communication specialists to develop and deliver a technology transfer plan including industry meetings, conferences (e.g., Livestock Gentec, Field days, Alberta Beef Forage and Grazing Centre meetings) and published reports. The results will be presented in multiple scientific meeting including Canadian Society of Animal Science meetings. The research findings will be circulated through Livestock Gentec newsletter and other magazines like The Western Producer. The research findings will also be published in animal journals such as Journal of Animal Science and Canadian Journal of Animal

Science.

In terms of industry partnership on the development or distribution of extension resources, Growsafe Systems Ltd. is prepared to work with up to 10 different ranches under a technology usage agreement (see below for details). Other communication efforts include: (1). The Livestock Gentec center has an experienced team working with beef cattle industry including Delta Genomics. Other team members including Dr. John Crowley from Canadian Beef Breeds Council, Dr. Ghader Manafiazar, a Research & Development Associate, Beefbooster Inc. Tom Lynch-Staunton, manager of government relations for Alberta Beef Producers and issues manager for the Canadian Cattlemen's Association, which will enhance communication, technology transfer and commercialization of the research results from the project. (2) The team will work with Growsafe Systems Ltd. for any IP management, ownership and commercialization. Growsafe will have first right of refusal to commercialize any project outcomes. Standard cooperative research and development agreement (CRADA) terms to apply – royalty provisions, etc. if there is commercial outcome. In addition, IP management, ownership and commercialization will be handled in accordance with the existing 'Canada-U of A Bovine Genomics Agreement', i.e. the co-location agreement between Agriculture and Agri-Food Canada (AAFC) and the University of Alberta (U of A), and as per the terms contained in the existing 'Collaborative Agreement' between AAFC, U of A and Alberta Agriculture and Rural Development (Alberta Agriculture and Forestry) for bovine genomics research, as well as in accordance with terms and conditions of the agreement for the current funding if awarded.

Industry Involvement

Have you identified any appropriate beef producers or other industry stakeholders who would be interested in working with you to get these results field tested, demonstrated, implemented, etc.? Please provide names and regional location of interested parties.

Growsafe Systems Ltd. is prepared to work with up to 10 different ranches under a technology usage agreement, hereafter referred to as Growsafe's On-Farm Phenotyping Approach. Ranches must agree to a 5 year usage agreement paying GrowSafe $10,000 per year that is paid in advance each year. This is NOT a fee paid by the project to the ranch. GrowSafe retains ownership of Growsafe technology installed on farm and GrowSafe data collected during on-farm phenotyping, and these data cannot be sold to a third party without written consent from Growsafe. Ranches must agree to share all pedigree and associated performance data with GrowSafe and project researchers. Project will agree to share on farm rancher associated data collected specifically during this project and outcomes with Growsafe. Growsafe will have first right of refusal to commercialize any project outcomes. Standard cooperative research and development agreement (CRADA) terms to apply – royalty provisions, etc. if there is commercial outcome. Other communication materials (e.g., factsheets, articles, and videos) specifically related to the project will be cleared through project leaders, funders, Growsafe Systems and other pertinent stakeholders. The Growsafe technology (feed intake and continuous body weight) to undertake this project would be $1,450,165 for ten farms.

Please provide other information that is pertinent to communication, technology transfer, and commercialization of these research results.
(1). The Livestock Gentec center has an experienced team working with beef cattle industry including Delta Genomics. Other team members including Dr. John Crowley from Canadian Beef Breeds Council, Dr. Ghader Manafiazar, a Research & Development Associate, Beefbooster Inc. Tom Lynch-Staunton, manager of government relations for Alberta Beef Producers and issues manager for the Canadian Cattlemen's Association, which will enhance communication, technology transfer and commercialization of the research results from the project. (2). IP management, ownership and commercialization will be handled in accordance with the existing 'Canada-U of A Bovine Genomics Agreement', i.e. the co-location agreement between Agriculture and Agri-Food Canada (AAFC) and the University of Alberta (U of A), and as per the terms contained in the existing 'Collaborative Agreement' between AAFC, U of A and Alberta Agriculture and Rural Development (Alberta Agriculture and Forestry) for bovine genomics research, as well as in accordance with terms and conditions of the agreement for the current funding if awarded. The team will also work with the industry partners such as Growsafe for any IP management, ownership and commercialization.
Total Project Budget
To be completed and submitted using Excel file entitled 'BCRC Proposal Budget'.

Approvals	
Project Leader Name: John Basarab Position: Research Scientist Signature: __________ Date:	Project Leader Employer Approval Name: Wesley Johnson Position: Director, Livestock Research Signature: __________ Date:
Co-Investigator Name: Changxi Li (co-Leader) Position: Research Scientist Signature: __________ Date:	Co-Investigator Employer Approval Name: Dr. Francois Eudes Position: RD&T Director Signature: __________ Date:

Table 1. Number of heifers measured or to be measured (**in bold**) for DMI and cows by winter feeding treatment, hybrid vigor score group and breeding season at the Lacombe Research Centre.						
Breeding season year	Heifers (9-11 mo. of age)		Cows (≥ 2 years of age)			
	Growsafe pens		CONFINED; higher input		PASTURE; lower Inputs	
	Above avg Vigor	Avg or below avg. Vigor	Above avg. Vigor	Avg or below avg. Vigor	Above avg. Vigor	Avg or below avg. Vigor
2007	51	10	76	10	0	0
2008	39	31	82	37	10	9
2009	27	34	91	57	6	7
2010	23	17	77	58	15	15
2011	54	40	92	75	32	33
2012	47	41	95+(20)	64+(20)	26	13
2013	47	38	85+(22)	62+(22)	15	21
2014	35	40	81+(20)	76+(21)	25	22
2015	37	49	91	112	30	37
2016	60	43	82+(10)	91+(11)	30	30
2017	42	45	79+(11)	90+(10)	30	30
2018	**40**	**40**	70+(20)	80+(20)	56	56
2019	**40**	**40**	70+(20)	80+(20)	56	56
2020	**40**	**40**	70+(20)	80+(20)	56	56
2021	**40**	**40**	70+(20)	80+(20)	56	56
2022	**40**	**40**	70+(20)	80+(20)	56	56
Total	662	588	1281+(183)	1132+(184	499	497

Individual animal feed intake tests over 76-84 days were also conducted on 166 cows from 2012-14 and 2016-17.
Numbers in parentheses refer to cows also tested for or to be tested for feed intake using the Growsafe System. Other cow numbers in these two columns refer to cows not tested for feed intake in Growsafe but fed under traditional confined winter feeding conditions.

Table 2. Number of heifers measured or to be measured (**in bold**) for DMI and cows by winter feeding treatment, hybrid vigor group and breeding season at the Roy Berg Kinsella Research Station.						
Breeding season year	Heifers (9-11 mo. of age)		Cows (≥ 2 years of age)			
	Growsafe pens		CONFINED, higher inputs		PASTURE, lower Inputs	
	Above avg Vigor	Avg or below avg. Vigor	Above avg Vigor	Avg or below avg. Vigor	Above avg Vigor	Avg or below avg. Vigor
2012	105	45	----	----	----	----
2013	85	46	----	----	----	----
2014	94	51	----	----	----	----
2015	100	43	22	20	100	50
2016	94	51	20	20	100	50
2017	86	47	20	20	100	50
2018	**80**	**40**	20	20	100	50
2019	**80**	**40**	20	20	100	50
2020	**80**	**40**	20	20	100	50
2021	**80**	**40**	20	20	100	50
2022	**80**	**40**	20	20	100	50
Total	964	483	162	160	800	400

Individual animal feed intake tests over 76-84 days were also conducted on 122 cows from 2015-17.

Appendix A

Table 1. Number of heifers (cows) measured or to be measured (**in bold**) for DMI and cows by winter feeding treatment, hybrid vigor score group and breeding season at the Lacombe Research Centre.						
Breeding season year	Heifers (9-11 mo. of age)		Cows (≥ 2 years of age)			
	Growsafe pens		CONFINED; higher input		PASTURE; lower Inputs	
	Above avg Vigor	Avg or below avg. Vigor	Above avg. Vigor	Avg or below avg. Vigor	Above avg. Vigor	Avg or below avg. Vigor
2007	51	10	76	10	0	0
2008	39	31	82	37	10	9
2009	27	34	91	57	6	7
2010	23	17	77	58	15	15
2011	54	40	92	75	32	33
2012	47	41	95+(20)	64+(20)	26	13
2013	47	38	85+(22)	62+(22)	15	21
2014	35	40	81+(20)	76+(21)	25	22
2015	37	49	91	112	30	37
2016	60	43	82+(10)	91+(11)	30	30
2017	42	45	79+(11)	90+(10)	30	30
2018	**40**	**40**	70+(**20**)	80+(**20**)	56	56
2019	**40**	**40**	70+(**20**)	80+(**20**)	56	56
2020	**40**	**40**	70+(**20**)	80+(**20**)	56	56
2021	**40**	**40**	70+(**20**)	80+(**20**)	56	56
2022	**40**	**40**	70+(**20**)	80+(**20**)	56	56
Total	662	588	1281+(183)	1132+(184)	499	497

Individual animal feed intake tests over 76-84 days were also conducted on 166 cows from 2012-14 and 2016-17.
Numbers in parentheses refer to cows also tested for or to be tested for feed intake using the Growsafe System. Other cow numbers in these two columns refer to cows not tested for feed intake in Growsafe but fed under traditional confined winter feeding conditions.

Table 2. Number of heifers (cow) measured or to be measured (**in bold**) for DMI and cows by winter feeding treatment, hybrid vigor group and breeding season at the Roy Berg Kinsella Research Station.						
Breeding season year	Heifers (9-11 mo. of age)		Cows (≥ 2 years of age)			
	Growsafe pens		CONFINED, higher inputs		PASTURE, lower Inputs	
	Above avg Vigor	Avg or below avg. Vigor	Above avg Vigor	Avg or below avg. Vigor	Above avg Vigor	Avg or below avg. Vigor
2012	105	45	----	----	----	----
2013	85	46	----	----	----	----
2014	94	51	----	----	----	----
2015	100	43	(22)	(20)	100	50
2016	94	51	(20)	(20)	100	50
2017	86	47	(20)	(20)	100	50
2018	**80**	**40**	**(20)**	**(20)**	100	50
2019	**80**	**40**	**(20)**	**(20)**	100	50
2020	**80**	**40**	**(20)**	**(20)**	100	50
2021	**80**	**40**	**(20)**	**(20)**	100	50
2022	**80**	**40**	**(20)**	**(20)**	100	50
Total	964	483	(162)	(160)	800	400

Individual animal feed intake tests over 76-84 days were also conducted on 122 cows from 2015-17.