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In This Issue

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Ministry of Agriculture, Food
& Rural Affairs

Ontario

Allocating grazing to maximize pasture and beef cattle performance

James Byrne, Beef Cattle Specialist, OMAFRA

There are many ways to measure annual pasture performance such as total annual dry matter yield, stocking rate achieved, livestock gain, etc. Ultimately, pasture performance is determined by (a) animal performance over the course of the grazing season, i.e. average daily gain, and/or (b) the number of animals, i.e. beef cows, that can be grazed on a pasture over the grazing season. The higher the average daily gain and/or the higher the total number of animals that can be grazed on an area of pasture, the greater the economic return at the end of the grazing season. Yield, though important and impacts the performance measures previously described, does not generate a direct economic return from grazed pasture.

The central driver for both these performance measurements is maximizing dry matter intake. In order to maximize dry matter intake, cattle must be able to utilize as much of the pasture dry matter allocated as possible. Pasture utilization is a measure of the difference between the amount of pasture dry matter grown versus the amount of pasture dry matter consumed. Pasture utilization is expressed as a percentage (%). Therefore, when we say that the pasture utilization rate is 60%, this means that 60% of the total pasture available for consumption was consumed, the remaining 40% was left in the field. Low pasture utilization rates impact individual animal performance, but more significantly, the number of animals that can be grazed on a pasture.

The ability of cattle to utilize pasture effectively depends upon the growth stage of the pasture at the time of grazing and the amount of pasture allocated. Pastures in the vegetative stage, (i.e. not headed out), are very digestible and cattle can consume a significant amount of pasture allocated when grazing pastures at this stage. However, as the pasture matures and heads out, digestibility declines and the amount of pasture consumed also declines. Pasture intake by cattle is also impacted by the amount of pasture allocated (Jouven et al., 2007). As the amount of pasture allocated increases, intake increases, but beyond 1,500 to 1,800 kg per hectare (for beef cows) increases in pasture allocation leads to only a marginal increase in pasture intake, indicating that there is a physical limitation to the amount of pasture cattle can graze effectively and that there is an ideal pasture allocation range. Keeping pasture in the vegetative stage as long as possible through good grazing management and proper allocation will maximize pasture utilization and pasture performance.

This impact of good utilization is illustrated below:

Over the course of a year a pasture produces 4,500 lb of dry matter per acre and the utilization rate is 50%. This means that 2,250 lb of pasture dry matter per acre are consumed by grazing livestock. A beef cow will consume approximately 3% of her body weight in dry matter daily, which over a 180-day grazing season amounts to 8,100 lb of dry matter. Where the utilization rate is 50%, this will require 3.6 acres of pasture to feed a single beef cow over the grazing season. Increasing the utilization rate from 50% to 70% reduces the area required to feed a single beef cow to 2.5 acres. Increasing the utilization rate reduces the amount of land that must be allocated to grazing, freeing up more land for other economic activities.

Another way to look at this is that 100 acres of pasture grazed at 50% utilization rate can feed 27 cows whereas the same area grazed at 70% utilization rate can feed 40 cows – an extra 13 cows. In this example, increasing the utilization rate from 50% to 70% provides the potential for 13 additional calves to be available to sell at the end of the grazing season leading to higher revenue return for the producer.

Research around the world has clearly demonstrated the impacts of different grazing systems on pasture performance and animal output per unit area. The least productive systems are continuous grazing systems with strip grazing considered the highest productive pasture management system. In order to provide feed to cattle over the whole grazing season from one location, continuous grazing systems require a large land area and low stocking rates. This results in very low pasture utilization rates and consequently low output per unit area. Strip grazing maximizes pasture utilization, pasture intake and consequently output per unit area by only allocating the amount of pasture dry matter required by the herd in a 12 or 24-hour period. Due to the labour intensity, labour cost and capital investment of strip grazing systems, they are well suited to pasture dairy production.

Set stocking and rotational grazing systems lie between these two extremes and are the most common form of pasture management system employed by beef producers. Under good management, both these systems can deliver excellent pasture performance through good utilization rates and consequently good output per unit area. Both labour and capital costs are modest in both these systems.

The critical component to increasing pasture utilization and consequently output per unit area is the accurate allocation of pasture dry matter. The amount of pasture dry matter to be allocated is determined by (a) stocking rate, (b) potential animal intake (% of body weight), (c) average rotation length and (d) an estimated amount that will not be consumed (i.e. the residue). By allocating pastures accurately, we can better control the rate of pasture usage, ensure a continuous adequate supply of forage and react to changes in pasture performance, i.e. slowing growth rate.

Pasture allocation is calculated from the following formula:

Pre-grazing herbage allowance = stocking rate (# of cattle per acre) x ideal rotation length (days) x herbage allowance per cow (lb DM/day) + residual herbage mass (lb DM/ acre)

Example: 0.5 beef cows per acre x 40 days x 45 lb DM/day + 450 lb (residual herbage mass) = 1,350 lb dry matter per acre.

In the example above, the pre grazing herbage allowance, i.e. the amount of pasture dry matter that should be in a field prior to grazing, is 1,350 lb per acre when the pasture is stocked at 0.5 beef cows per acre and where the rotation length is 40 days. The residual herbage mass is the amount of pasture that should be left behind in the pasture after grazing to ensure adequate pasture growth for the next rotation. There is no agreed post grazing residual for Ontario pastures. However, using the rough rule of thumb of "take half leave half", the residue can be calculated as follows:

Stocking rate (# of cattle per acre) x rotation length x herbage allowance, (estimated DM intake, lb/day) X 50%.

There are several methods available to determine the amount of pasture dry matter in a pasture. The most accurate, although laborious, is the cut and weight method using a quadrat, drier and scales. Using a rising plate meter is a quick and easy method of estimating the amount of pasture in a field. With this method 30 to 50 compressed pastured heights are taken randomly across the pasture using a rising plate meter and the average compressed pasture height calculated. To convert compressed grass height to lb per acre requires knowledge of pasture density. Pasture density is the lb of pasture per cm or inch of height.

Pasture density is calculated using the formula below:

Pasture density (lb DM per cm height) = herbage mass; lb dry matter per acre divided by average compressed sward height in cm.

To calculate sward density requires a knowledge of the herbage mass in the pasture, which will need to be calculated using the cut and weight method. However, once calculated this density should remain true for several years provided there are no major changes to the pasture, e.g. reseeding.

Once the pasture density is known, calculating the DM content in a pasture becomes relatively simple. It is calculated as follows:

Average compressed sward height (in cm) – 5 cm (target post grazing height) x sward density. For example:

A pasture has an average compressed sward height of 15 cm and a sward density of 120 lb of DM per cm of height per acre. Therefore, the calculation becomes:

15 cm (pre-grazing calculated sword height) – 5 cm (target post grazing sward height) x 120 lb = 1,200 lb DM per acre.

The target post-grazing sward height is the lowest level cattle could be allowed to graze which maximizes the amount of pasture available but leaves enough pasture behind to encourage good growth for the next rotation. This number typically increases as the grazing season progresses and the amount of undigestible plant material accumulates at the bottom of the pasture. A good guide of thumb is to graze to 5 cm for the spring rotation and increase this level thereafter.

Allocating pasture to meet herd demand will significantly improve pasture performance leading to higher animal performance and greater output per unit area.

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Using linear calf measurements, "big data" techniques, and new camera-based technology to assist with animal management

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Management decisions based on body weight are vital for improving farm efficiency. Body weight is a key management tool used to identify cattle growth, diet conversion, health, and the efficiency of beef cattle; these attributes contribute to production, efficiency, and profitability. The use of a scale and body condition score has shown to help producers benchmark cattle and make improvements in their operation. However, many producers do not have access to weigh scales or the facilities or labour to routinely weight cattle. This is particularly a challenge on pasture-based management systems. According to the 2018 Ontario Cow/calf production survey, only 44% of producers used a scale on their operation. Weights or measurements taken regularly may be able to uncover trends that will enable producers to detect health or management issues early, and adjust or treat cattle to maintain growth production and efficiency.

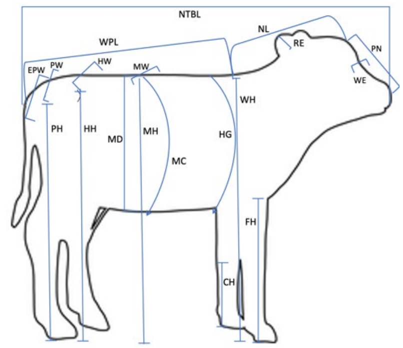


Diagram of 19 linear body dimensions traits measured on young beef calves

There has been a growing interest in exploring precision agriculture and big data in livestock production systems. “Big data” refers to collecting large amounts of daily information and using those records to extract knowledge that benefits an industry. Additionally, precision agriculture uses innovations in engineering and merges it with agriculture science. In our study new innovations in big data in using visual spectral data from camera systems, may be used to be able to passively collect data from beef calves to predict body weight and growth.

Linear Measurements vs. Body weight

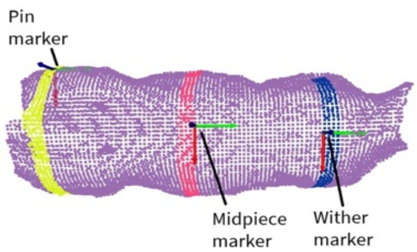
This proof-of-concept study, brought together researchers Dr. Medhat Moussa from the School of Engineering and Dr. Katie Wood and graduate student Vanessa Rotondo from the Department of Animal Biosciences, along with OMAFRA industry experts to develop a system that passively collects calf images and see if those images can be used to automatically identify key body points, and to determine if these linear body measurements can be used to accurately predict body weight. The study was conducted at the Ontario Beef Research Centre. A total of 103 calves-- 57 heifers and 46 bull Angus cross calves, were enrolled in the study and weighed and measured weekly from two weeks to eight weeks of age. The following 20 body characteristic were measured: poll to nose (PN), width across the eyes (WE), width across the right ear (RE), neck length (NL), wither height (WH), heart girth (HG), midpiece height (MH), midpiece circumference (MC), midpiece width (MW), midpiece depth (MD), hook height (HH), hook width (HW), pin height (PH), top of pin bones width (PW), width across the ends of pin bones (EPW), nose to tail body length (NTBL), the length between the withers and pins (PWL), forearm to hoof (FH), cannon bone to hoof (CH) and body weight. These measurements and weights were taken using a commercial soft tape measuring tape, calf scale, and calipers. To develop prediction equations for predicting body weight, body trait measurement data were analyzed using Weka (The University of Waikato, New Zealand), a machine learning system. The results show that linear measurements are tightly correlated with body weight (r^2= 0.97). Additionally, the most influential traits within the body weight prediction equation are heart girth, width across the eyes, and pin width. Identifying these key traits is important, such that the Computer Vision (CV) technologies can be fitted to obtain these measurements automatically from the RGB-D camera images.

Measuring over 19 body dimensions traits on young beef calves at the Ontario Beef Research Centre Measurements

RGB-D image capture system

Once the physical measurements were taken, the calves were lead using a halter to the prototype RGB-D image capture system. The calves were positioned in the middle of the camera system to enable the system to collect the images. Two Intel® RealSense™ D435 cameras were used to capture RGB-D data. The RGB-D cameras were mounted on either side of a wooden frame: 750 mm apart and 1400 mm from the ground. Each calf had approximately 10 to 15 images collected. Images from the RGB-D system were compared to the location and accuracy of physical measurements. The visual spectral data was able to identify the calf from the background, identify the width at the withers, midpiece, and pins with good accuracy.

Calf standing under the prototype camera system used to capture visual data to estimate body weight



Data generated by the camera system used to identify key traits in order to calculate body weight

Future Application

This study was successful in measuring key linear body traits important to predicting body weight in calves. This development of this type of system has many applications going forward. For calves, the future expectation is to further develop the prototype to have the camera in a creep pen or on a feeding system to allow for automatic constant data collection of calves instead of the wooden frame used in the study. Although only focused on calf body weight, this technology may be useful in early prediction of growth curves and weaning weight, so producers may be able to make early management decisions on young calves. In addition, future work needs to be done to validate this technology for use on older animals. New technologies using "big data" systems can be integrated into livestock productions systems and may provide another tool to improve beef cattle production.

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Bunk Management and Cattle Feeding Behaviour

The relationship between bunk management and cattle feeding behaviour

**Megan Van Schaik, Beef Cattle Specialist, and
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Bunk management is a common topic for discussion amongst feedlot operators because it is a central practice to feeding cattle. Improper bunk management can result in digestive disorders, inconsistent dry matter intake, and poor performance, and it ultimately affects a cattle feeder's bottom line. It is estimated that poor bunk management can reduce dry matter intake and average daily gain by up to 10-15%. Bunk management plays a big role in maintaining rumen health.

Slick bunk approach and cautions around length of time the bunk is empty

Slick bunk management is an effective approach to managing feed intake and reducing feed waste when managed well. Situations where cattle are offered feed ad-libitum or inconsistent deliveries can lead to yo-yo intakes and the reoccurrence of off-feed incidences.

The challenge is striking a balance between overfeeding and underfeeding. The ultimate goal of bunk management is matching feed deliveries to dry matter intake (DMI) to achieve desired performance. Concerns with leaving the bunk empty for too long include poor gains, reduced feed efficiency, reduced carcass quality, longer days on feed, and increased risk of digestive upsets (fluctuating intake) which can lead to other health issues.

Bunk Scoring – A Tool for Reading Bunks

Researchers from South Dakota State University have developed a 4-point bunk scoring system that assists feedlot operators in consistently and objectively monitoring intake.

The 4-point bunk scoring system

Score	Description
0	No feed remaining
½	Scattered feed remaining; most of the bottom of the bunk is exposed
1	Thin uniform layer of feed remaining (~ 1 corn kernel deep)
2	25-50% of feed remaining
3	Greater than 50% of feed remaining with crown thoroughly disturbed.
4	Feed is generally untouched. Crown of feed from previous feed still noticeable.

Adapted from Pritchard, R. South Dakota State University (SDSU).

This scoring system helps operators estimate actual DMI rather than rely solely on feed delivery records.

If slick bunk is the goal, these questions need to be raised:

1) How long is the bunk actually slick/empty for? and
2) Are feed deliveries matching actual target DMI and the appetite of the pen of cattle?

Results from a recent joint study by OMAFRA and the Ontario Corn-Fed Beef Program suggest that the bunk may be empty longer than a feeder realizes.

Cattle Feeding Behaviour is Influenced by Bunk Management Approach

In a 2020 bunk management study jointly coordinated by the Ontario Corn-Fed Beef Program and OMAFRA staff, trail cameras were used to monitor cattle feeding behaviour, bunk scores, and bunk management approach (specifically, timing of feed deliveries and feed push-ups). Using the 4-point SDSU bunk scoring system, bunks were assessed hourly (and more frequently around feeding times) to observe intake behaviours over a cycle of at least 72 hours on six farms in Ontario.

Figure 1a). *Daytime image of a feed bunk from a trail camera at a participating farm.*

Figure 1b). *Nighttime image of a feed bunk from a trail camera at a participating farm.*

Academic research and practical experience tell us that success in bunk management is anchored in consistency and diligence in monitoring. Consistency is important in many aspects of feeding, including timing of feeding, timing of when bunks are read before feed deliveries, the person reading bunks and delivering feed, feed mixing order and mixing time. Promoting consistency in feed delivery helps to stabilize ruminal fermentation and pH to improve feed efficiency. There is a large body of evidence that supports the practice of feeding multiple times a day (more than once) to improve performance of cattle**.** Feeding less, more often helps to reduce stress on cattle coming to the bunk by decreasing aggression. With increased feeding frequency, cattle generally consume less at each visit but visit the bunk more, resulting in more consistent feed intake and better rumen health.

Figures 2 a) and b) illustrate feeding behaviours associated with feed deliveries and feed push-ups in 24 hours, where these activities encouraged cattle to visit the bunk. These figures are examples of data obtained from the trail cameras and graphed. The black line represents the number of cattle feeding at the bunk (expressed as a percentage of bunk capacity) and the green bars represent bunk scores (representing feed disappearance and deliveries over time). The vertical lines represent feed offerings, with the red lines representing fresh feed deliveries and the blue lines representing feed push-ups. These data collected and trends observed confirm the importance of frequent feeding and/or feed push-ups in attracting cattle to the bunk for meals for more consistent feed intake.

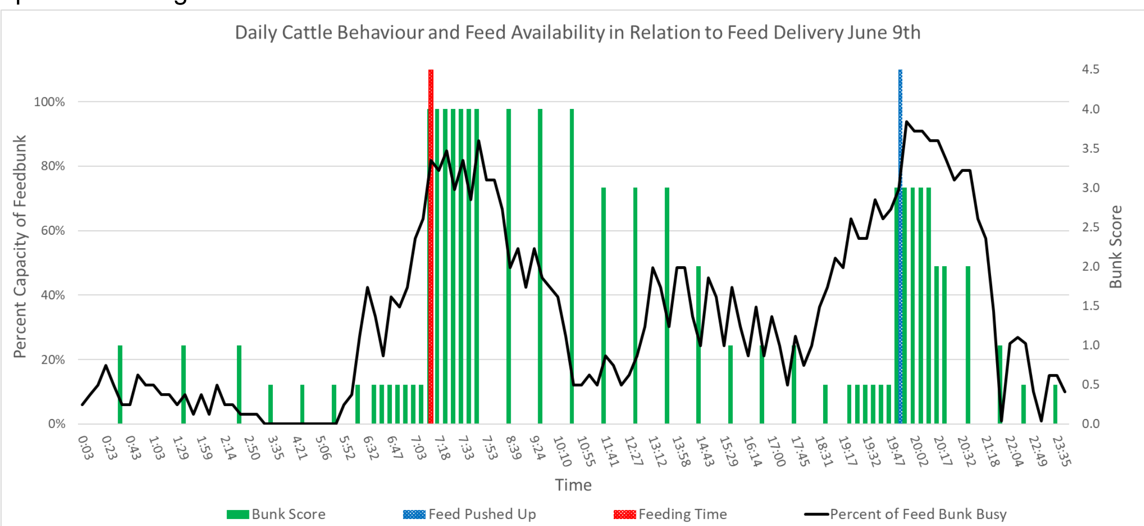

Figure 2a). *Feeding behaviour and bunk score over time, where time "0" is midnight.*

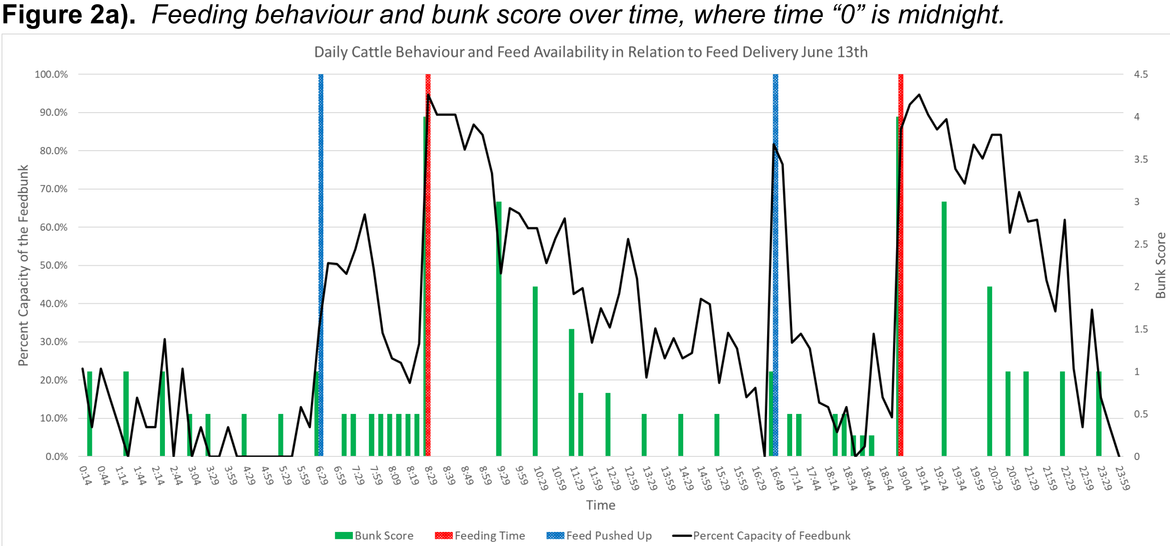

Figure 2b). *Feeding behaviour and bunk score over time, where time "0" is midnight.*

Similarly, reducing the amount of time the bunk is empty improves consistency in intake. On average, bunks were empty for 5.5 hours in a 24-hour time period across the farms studied in 2020. The maximum time a bunk was empty during the study across farms was 13 hours in a 24-hour period. In contrast, the benchmark to strive towards is to keep the bunk slick for 1 hour or less before feeding.

Using Information to Manage Bunks

Monitoring feeding behaviour over time and assessing exactly how long bunks are empty for can be a challenge, compounded by off-farm work and fieldwork. Trail cameras are excellent tools to monitor cattle behaviour and assess bunk management strategies. They can be used to shed light on the impact of specific practices without the interference of human observers and are valuable in capturing data over time. *Figure 3* provides an example of what feeding behaviour data looks like graphed over time (in this case three days) for one of the study's participating farms.

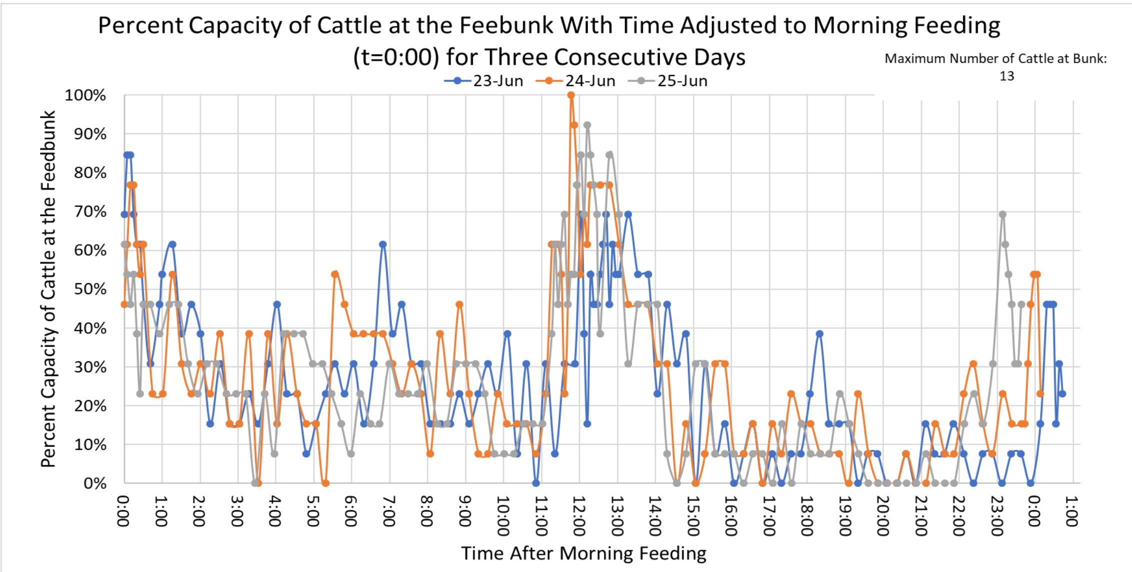

***Figure 3**. Number of cattle at the feed bunk (expressed as a percent of the capacity of the feed bunk) over three days (each line representing a different day). Time "0" represents time of morning feeding.*

Practically speaking, it is not feasible to use trail cameras to collect information and assess cattle feeding behaviours on a daily basis as was done in this study, but there are other tools that can be used routinely that lend to sound bunk management. While each cattle feeder will develop their own approach to using information from bunk reading, the use of a bunk scoring tool such as the 4-point bunk management tool developed by South Dakota State University can help an operator collect important information on DMI every day. This scoring system is most effective when it is used to read bunks on a daily basis and when the information is used to make decisions for feed deliveries over a number of days. For example, the information can be used to decide whether:

- **Feed deliveries should be increased.** Increases in feed deliveries should be considered after observing 3-4 days a slick bunk (i.e. score of 0) when the bunk is read before feeding.
- **Feed deliveries should be reduced.** Reducing delivered feed should be considered after observing 2 days of feed left in bunk (i.e. score of 1 or more) to avoid overfeeding and deterioration of feed quality.
- **Feed deliveries should be maintained.** A bunk score between 0 and 1 suggests that intake is consistent and feed deliveries can be maintained.

Keep in mind that making aggressive changes to feed deliveries can disrupt intake and cause yo-yo feeding behaviour. Gradual changes reduce the potential for feed intake disruptions and digestive upsets, where changes to feed deliveries do not exceed 3-5% on a dry matter basis. The next level of using bunk scoring is graphing this data over time, which allows the operator to visually see trends in dry matter intake over a feeding period.

There are lots of factors going into making feed delivery decisions (sometimes referred to as 'feed calls'), including cattle behaviour, manure consistency, cattle health, weather patterns, etc. Ideally feed calls are made by the same person every day. Those making feed calls should be familiar with the pen of cattle and recent history of feed deliveries.

Observing the aggressiveness of cattle at the bunk is another monitoring mechanism that when paired with bunk scoring can help an operator understand the appetite of cattle and guide decision making when it comes to feed deliveries. It is desirable to see about 25% of cattle approaching the bunk for feed during feeding. Observing overly aggressive cattle during feeding is often an indication that cattle are hungry.

The authors would like to recognize project members Brent Cavell (Quality Assurance Manager, Ontario Corn-Fed Beef Program), Christoph Wand (Livestock Sustainability Specialist, OMAFRA), and Julie French and Katelyn Sysiuk (2020 summer livestock assistants, OMAFRA).

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Understanding the biological differences between high-fertile and sub-fertile beef cows through interactions between genes

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In the last number of decades, a decrease in fertility efficiency has been observed due to an intensive selection pressure in both beef and dairy cattle populations. Poor fertility and reproductive inefficiency are among the main causes of reduced profitability of both beef and dairy herds (Bellows et al. 2002; Shalloo et al. 2014). Sub-fertile cattle can cause further economic losses to producers once these animals generate progeny, consequently maintaining the “bad” alleles (or markers) for this phenotype in the population (Id-Lahoucine et al. 2019; Sweett et al., 2020). On the other hand, the alleles responsible for the infertile phenotype tend to be reduced over time due to the absence of progeny carrying these alleles.

Reproductive traits are considered complex phenotypes as they present a high heterogeneity, high environmental impact, and do not follow a Mendelian inheritance pattern. Consequently, the identification of functional candidate genes and genetic variants for complex traits can be a complex process. RNA-Sequencing technology has been used to better understand the genetic architecture of fertility in beef cattle (Dias et al., 2017; Nguyen et al., 2017). This has enabled the identification of several candidate genes and genetic variants for this trait. However, this approach can overestimate the genetic interactions across genes, which is one of the most important processes for development of complex traits such as fertility. Genes that play a role in the same biological processes tend to be regulated by similar regulatory mechanisms or even interact with each other. Consequently, the expression of genes that act in the same processes tend to be correlated. In other words, genes which are responsible to regulate similar biological processes will be recruited by the cells in proportional intensity. For example, a group of genes can have the expression increased while other group of genes will have the expression decreased. However, these genes will follow the regulatory stimulus that controls the biological process in that tissue. To keep the fine regulation of the complex interactions between genes that compose a complex trait, these genes tend to have a correlated expression and alterations in its expression will follow a similar magnitude independent of the direction (increase or decrease). The use of co-expression gene networks can be an useful approach to identify this correlation pattern, leading to the identification of regulatory and functional mechanisms responsible to regulate the development of complex traits, including those associated with fertility.

As part of one of the research performed at the Cánovas Lab at U of G, the RNA-Sequencing data from uterine samples of high-fertile (HF) and sub-fertile (SF) beef cattle were integrated using co-expression network meta-analysis. Briefly, here we combined different RNA-Sequencing data to identify the groups of genes for which the expression was correlated in a unique way in one of the groups of HF and SF animals. Additionally, the prospection of genetic variants (markers including single nucleotide polymorphisms (SNPs) and insertions and deletions (INDELs)) that were uniquely identified in genes present in the network of correlated genes in HF or SF animals was also performed. As result, we were able to identify those genes with the largest number of interactions (the expression was correlated with a larger number of genes) and also harboured unique genetic variants for HF or SF animals. A total of 32 genes were identified as potential functional candidate genes for HF and SF status. These genes were co-expressed with a larger number of genes in a unique way in HF or SF animals and also harboured genetic variants fixed in one of the groups of animals. These genes were associated with the regulation of relevant biological processes for fertility, such as embryonic development, germ cell proliferation, and ovarian hormone regulation. A total of 100 candidate genetic variants were identified within those genes, which can be further used in association studies. Once the association with the fertility status of the animals is confirmed, the results can be used in genetic selection schemes.

As result of this study, we identified highly relevant functional gene networks and candidate genes associated with fertility status in beef cattle. These results contribute to a better understanding of the genetic architecture of high- and sub-fertility cows due to the integration of multiple sources of information. Additionally, markers were identified as uniquely fixed in one of the fertility groups (HF or SF animals) in functionally relevant candidate genes. These variants could be used in genetic selection programs to validate the contribution of the variants in fertility status. In the long-term, the results obtained here may help to reduce the frequency of subfertility in beef herds, helping to reduce the economic losses for the beef industry.

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