

Developing technology to drive change in the beef industry

Alison Sunstrum, Camiel Huisma
GrowSafe Systems Ltd, Airdrie, Ab. Canada, T4B2A3

Introduction

Within the next 30 years the world's farmers and ranchers will be called upon to double food production, on essentially the same land, and do so in environmentally sustainable ways.¹ Canadian farmers lost money 7 out of the last 10 years.² Over the past twenty years negative farm profit is reported in Australian data.³ Although there are regional differences, globally the beef industry is dealing with historically high input prices, animal disease, antimicrobial resistance, and consumer perception about beef safety, animal welfare and carbon footprint. Each of these issues has the potential to structurally change the industry. Industry sustainability and possibly food security requires significant productivity gains that must be inextricably linked with improved farm profitability; a challenge which the authors contends can only be met by disruptive innovation.

Feeding Behavior Monitoring

In the early 1990's GrowSafe engineers pioneered a Radio Frequency Identification (RFID) based computerized data acquisition system that electronically identified and monitored ostrich chicks. This required the development of a method to read multiple transponders in close proximity automatically without confinement. Chicks visited the feeder about 500 times per day. When chicks became ill, visitation dropped rapidly, declining to about 50 visits per day. This visitation decline could be trended over a very short time interval, usually within 4 to 12 hours. In response to GrowSafe data triggers, avian specialists developed responsive treatment protocols. Survivability was improved from 8% to more than 90% using GrowSafe technology and responsive treatment protocols.⁴

The technological transition from a GrowSafe system that could measure a small bird confined in a controlled environment to a large animal in the cattle environment was extremely complex and required the adaptation and invention of new electronics, wireless communication methods, and data acquisition and analysis techniques.

Early findings in cattle using GrowSafe technology indicated similar early predictive abilities using animal behavior to early identify illness. From 1993 to 2000 a significant body of early stage work was compiled by researchers using first generation GrowSafe behaviour research technology indicating that feeding behavior patterns of morbid and non-morbid calves differ,⁵ could be measured,⁶ and that the technology had the potential to identify morbid animals, before overt disease symptoms could be detected.⁷ Recently, researchers have begun to look again at the potential to use feeding behavior as an early diagnostic method of identifying sick cattle.⁸

From 2000 to early 2003 the company attempted introduction of behavior monitoring to the feedlot industry. At this time, the solution offered by GrowSafe technology was not considered feasible in an industry that had no mandate, or perceived economic benefit to RFID tag or change business practice to individually monitor cattle.

Feed Intake and Behavior Monitoring – Measuring Residual Feed Intake

A GrowSafe feed intake system reads the RFID tag, and measures the RFID antenna equipped feed trough each second with 10 gram resolution. Continuous data acquisition identifies non-tagged animal, environmental and other events; the system is capable of measuring below the noise floor, and along with an iterative filtering process accounts for these occurrences. A 'preceding, proceeding' weight data algorithm calculates the 'current' trough weight. This enables measurement of feed intake accurately in an outside production environment.

A 'GrowSafe digital feeding behavior signature' is like a fingerprint, a unique code comprised of a number of measured parameters. We have discovered that if we have a few weeks of data, with an animal identification number included, and then follow this with a few weeks of blinded data" (no animal ID) we can juxtapose the two data sets correctly matching the identified and non-identified animal data. This discovery laid the foundation for the predictive individual animal performance models used by commercial GrowSafe dairy and GrowSafe Beef™ feedlot systems. These models 'learn' how a specific individual animal typically behaves and can assess, usually within a matter of hours, when this typical behavior begins to change. We have found that changes in behavior precede disease and oestrus onset.

GrowSafe Feed Intake systems are used primarily to measure residual feed intake (RFI). RFI represents the amount of feed consumed, net of the animal's requirements of body weight and production. Efficient animals eat less than expected and have a negative or low RFI, while inefficient animals eat more than expected and have a positive or high RFI. There is conclusive scientific evidence that cattle with low RFI consume less feed at the same level of production as high RFI cattle. In addition to reducing feed consumption, cattle with low RFI produce less methane from enteric fermentation and also less manure relative to high RFI cattle, due to the fact they consume less feed. Selection for Residual Feed Intake (RFI) can reduce feed intake by 10-12%, methane by 25-30% and manure N, P and K by 15-17%.⁹ Australian¹⁰ and global research has demonstrated that efficient calves become efficient adults and progeny of low RFI cattle are more efficient. GrowSafe feed intake monitoring technology has become the gold standard for feed intake measurement in production environments. These systems are used to measure feed intake in dairy and sheep.

Developing Feedlot Individual Animal Management Systems

Building on the data acquisition platform developed for the feed intake system; from 2007 to 2010 GrowSafe invested significantly in design engineering, advanced software development and field validation. This included development of next generation microprocessor technology which greatly increased data throughput under increased data acquisition loads, improved bi-directional communication and reduced power consumption to enable solar power. The primary outcome of this development was a highly automated, feedyard practical system that monitors individual animal performance to the most optimal management, treatment and market end-point; an in pen data acquisition device known as GrowSafe Beef™ (GSB™).

GSB™ growth patterns are predictive of marbling, fat deposition and other factors enabling a feedlot operator to feed animals to specific grid based carcass specifications. Through continuous monitoring, behavior change, and growth change patterning GrowSafe can identify sick animals, usually before symptoms are expressed.

How GrowSafe Beef™ Technology Works

1. Animals are tagged with passive low frequency radio frequency identification (RFID) NLIS compliant ear tags. Each tag is a unique number.
2. The tag is read by an RFID antenna when the animal drinks.
3. A partial body measurement device is positioned in front of the integrated water trough. The animal naturally places his front two legs on the measurement platform when he visits the water trough.
4. Individual water intake is measured by individual drinking 'bowls' formed within the water trough. One unit typically has six drinking positions monitoring one pen containing about 250 animals.
5. The partial body weight, water intake and data from other sensors are continuously acquired during the drinking event.

The GSB™ partial body measurement platform and integrated RFID antenna are held in suspension. The load cell is mounted in the upper section of the metal frame which supports the structure. The platform has been designed in such a way that only the vertical forces are being measured by the load cell. The load cell and RFID antenna are connected to a data acquisition panel which samples the RFID antenna every 125 ms, and the load cell every 0.97 ms at a resolution of 30 grams. The GSB™ system draws very little energy (5.4 watts) and can be solar powered. Aggregated data is transmitted wireless up to 50 miles line of site to a standard data acquisition computer running a Windows, Mac or UNIX operating system. The data is continuously recorded to the hard drive. At the end of each day the acquired data is processed into usable information.

Daily data processing consists of multiple routines. A taring algorithm computes the weight of the support structure when no animals are present including any debris that may have been

left from the previous animal. The system calculates the weight of the individual animal adjusted by the tare weight. The weight data is processed using a linear regression technique using alternative time basis. The different time based observations are then stored in a data base for rapid retrieval by analytical routines. Data is seamlessly integrated into ODBC compliant feedlot databases.

The system reports individual animal daily body weight and gain, and forecasts future body weight and intake. Individual animal health status is parameterized based on water intake, drinking behavior, predicted feed intake, weight and gain. The system determines performance outliers, animals requiring treatment and the optimum time to market each animal when cost of gain begins to exceed value of gain. These statistics are updated daily.

When an outlier animal is identified, a signal is sent to the measurement unit which visually identifies (spray paints) the animal next drinking visit.

The system has the ability to treat an individual animal with up to 4 water soluble compounds automatically without human intervention. This aspect of the system is the focus of current investigation in collaboration with researchers and animal health companies.

Beyond the technical sophistication, the single most valuable attribute of the system is that it has been proven reliable and robust. It has been torture tested in the feedlot environment under extreme conditions in several geographical locations.

Conversion from Partial Body Weights

The GSB™ statistics presented below confirming measurement accuracy and precision were collected at a feedlot located in Airdrie, Alberta Canada during the period of November 2, 2010, and June 18, 2011. Two pens each housing 210 animals were used. Animals were weighed on arrival, on re-implant and each time animals were treated. A total of 1883 chute weights were obtained over the trial period. Harvest data was collected on all animals. Animals in this feedlot drank an average of 8.71 times per day and spent 669 seconds in front of the water trough.

Live weight, recorded by a full body chute is the common weight measurement for fed cattle because it is currently the only measurement possible. The industry uses a few rule of thumb conversions from live weight to express the value the feedlot is paid for. The most typical North American quality cattle value is Hot Carcass Weight (HCW). HCW is the weight determined by the processor of the carcass prior to chilling with its hide, head, gastrointestinal tract, and internal organs removed.

Standard Weight Factor: To convert a GSB™ partial body weight to a live weight or a HCW requires a factor. We have determined that the standard weight factor for conversion to full body weight is 1.83 and to HCW is 1.02.

Individual Weight Factor: By using a standard weight factor we recognize that we may be introducing some uncertainty into our measurement. Animals vary in size and type and our standard factor may not account for this. We sought to reduce the uncertainty in our standard factor by determining an individual weight factor which the system derives by incorporating full body chute weights. We developed software to automatically filter incorrect chute weights, weights that varied more than 60 lbs from the GSB™ partial body weight multiplied by the standard fully body weight factor (1.83), and from this we derive an individual weight factor for each animal.

When we correlate the 1883 chute weights to our GSB™ weights using a standard weight factor the correlation is 0.92 R². When we correlate the chute weights to our GSB™ weights adjusted by an individual weight factor, the chute to GSB™ correlation was increased to 0.95 R². Only a minor accuracy improvement was gained in live weight estimation by using the individual weight factor. This tells us that incorporating full body weights to the algorithm adds very little to our measurement.

Of more interest is the relationship between GSB™ weights and HCW. The correlation of predicted HCW based on several different time intervals of partial body weight is strongest using 7 days of GSB™ data prior to shipping date with a correlation coefficient of 0.89 R². When we correlate GSB™ partial body weights adjusted by the individual weight factor we found that by incorporating chute weights we actually reduced our accuracy when measuring HCW. (0.84 R²) Simply stated, we are about 90% accurate in predicting HCW of animals using GSB™ data about 7 days prior to shipping.

A feedyard would rarely consider processing animals through a chute prior to market due to stress, bruising and resulting shrink. We have determined that weights taken through a commercial chute when used at the day of slaughter would predict HCW with a correlation coefficient of 0.68² R. The reason for this is largely due to fill. In adult cattle, gut fill may account for between 12 to 22% of live weight.¹¹

Average Daily Gain

The data used to determine the ADG variation observed during consecutive and multiple chute weighing was obtained from numerous commercial and University residual feed intake trials.

When measuring ADG with a chute over a one month time frame 1 SD was 1.63 lbs. Over a 60 day time frame 1 SD ran at 0.82 lbs. and over 90 days 1 SD was 0.39 lbs. In other words, when measuring ADG with a chute over a 3 month time period ADG measurements can be in error by 1.2 lbs/day. In comparison when using a seven day time frame, GSB™ calculated ADG with a 99% confidence interval of 0.4 lbs/day.

The large number of weight samples GSB™ takes each day gives the feedyard an unprecedented precision in measuring average daily gain. GSB™ is capable of predicting

weight change with confidence 30 or more days into the future. This information can be used to determine carcass value of the animal and pinpoint optimal economic market endpoint.

If asked the question which calf is ready for marketing, one weighing 1100 lbs or 1300 lbs, the obvious answer would be the 1300 lb steer. However, if you also knew from GSB™ data that the 1100 lb steer was gaining 1 lb per day and the 1300 lb steer was gaining 4 lbs per day, would you have the same answer? Likely not, the larger steer was profitable, and the lighter steer was not.

Identifying Sick Cattle

The usual means of assessing the health of beef cattle are subjective, involving visual evaluation aided by minimal clinical measurements.¹² Animals are judged ill when they appear depressed, listless, or off feed. A dilemma facing modern feedlots is how to detect animals that are in need of medical intervention.¹³ Several studies have demonstrated that the impact of feedyard disease extends far beyond the cost of medication, death loss, and reduced animal performance, emphasizing the importance of prevention as early as possible. The value of rapid diagnosis and treatment of disease increases when cattle are sold on carcass merit basis because of the negative effects of disease on carcass traits.¹⁴ Epidemiological studies have indicated that even with increased pharmaceutical use, the incidence of morbidity and mortality in North American feed yards has increased.¹⁵

Using GrowSafe Beef™ Data as an Indicator of Disease

In October, 2010 supported by a team of epidemiologists, immunologists and veterinarian specialists GrowSafe undertook a GSB™ validation trial in 2 commercial feed yards in Alberta, Canada monitoring 739 animals in four pens. High risk auction barn cattle were sourced. The objective was to determine if multiple measurements acquired continuously in the feedyard in real time can be built into a computerized algorithm that profiles and identifies disease occurrence in advance of current feedyard visual assessment.

The feedyard health crew were instructed according to protocols provided by the feedyard veterinarian with standard operating procedures for processing and treatment of the calves. The feedlot health crew made all decisions regarding health intervention and treatment according to their standard operating procedures and recorded all diagnostic assessments. Feed intake, water intake and body weight and growth performance were measured in real-time with GrowSafe Beef™ and GrowSafe Feed Intake™ technology. GrowSafe data was not provided to the feedlot crew when making treatment decisions. Cattle were harvested in June, 2011. Harvest data was collected on all animals.

To determine how accurately the GSB™ intervention algorithm would perform, required us to determine how accurately the feedyard currently identifies sick cattle. We looked to veterinary literature. We found no standardized definition of morbidity. We found that

generally morbidity is defined by treatment rates. In the literature, if an animal is treated it is considered sick.¹⁶

A review of morbidity and mortality rates and disease occurrence in North American feedlot cattle indicate that around 15% to 45% of incoming calves require treatment, and around 1% to 5% die. In this trial mortalities were 3.4%.

An initial review of the GrowSafe data indicates that we would have agreed with the feedyard crew's assessment to treat 24% of the animals. GrowSafe data disagreed with 65% of the animals pulled and treated, average treatment cost was about CDN \$20.00 per animal. GrowSafe data indicated that these animals were eating, drinking and gaining. 29 animals that would have been identified by GrowSafe data were not identified by feedlot crew. There is much we need to investigate further before we make concrete statements about what this data means. Let's say for now, that it is an incredibly difficult job to identify sick cattle based on visual assessment of clinical symptoms.

Conclusion

In an industry currently relying on visual identification of sick and market ready animals, GrowSafe automation brings an objective decision making tool to the feedyard and an unprecedented opportunity to manage every animal precisely to the best of his welfare, while mitigating risk and optimizing profit. In the future, this type of automated standardized data acquisition protocol will better assess the efficacy of various therapeutic strategies, and enable more objective relevant comparison between animal studies.

There is no roadmap for individual animal management. In the feedlot industry benchmarks, pharmacological technology, much of the science and research, and our pre-conceived notions are all based on pen-based management. Lead users of GSB™ technology need to confront some challenging concepts that defy conventionally held wisdom but when they do they may find significant competitive edge. Disruptive innovation requires us to do things differently. A far greater thinker than we stated that we cannot solve our problems with the same thinking we used when we created them.

Corresponding Author: als@growsafe.com

Literature Cited

- ¹Norman E. Borlaug April, 2001. Feeding the World in the 21st Century: The Role of Agricultural Science and Technology. Extract from Speech given at Tuskegee University
- ² Destination Report, February 2011, Canadian Agri Food Policy Institute, Page 6.
- ³ Lagura, Erwin, Ronan, Glenn. 2010 How Profitable is Farm Business in Australia? Australian Agricultural and Resource Economics Society, Conference (54th), February 10-12, 2010, Abstract
- ⁴ USDA Quarantine data 2003, GrowSafe trial data, Huisma Anecdotal
- ⁵ Basarab, J.A., Milligan, D., Hand, R. And Huisma, C. 1996. Automatic monitoring of watering behaviour in feedlot steers: Proc. Can. Soc. Anim. Sci. 46th Annual. Conf., July 7-11, 1996, Abstr. 55, p 28.
- ⁶ Quimby, W. F., B. F. Sowell, J. G. P. Bowman, M. E. Branine, M. E. Hubbert, and H. W. Sherwood. 2001. Application of feeding behaviour to predict morbidity of newly received calves in a commercial feedlot. Can. J. Anim. Sci. 81:315–320.
- ⁷ Sowell, B. F., J. G. P. Bowman, M. E. Branine, and M. E. Hubbert. 1998. Radio frequency technology to measure feeding behaviour and health of feedlot steers. Appl. Anim. Behav. Sci.59:277–284.
- ⁸ Weary, D.M., Huzzey, J.M. von Keyserlingk, M.A.G. 2009 BOARD-INVITED REVIEW: Using behavior to predict and identify ill health in Animals J Anim Sci .87:770-777.
- ⁹ Agri-Facts, July 2006, Alberta Agriculture Agdex 420/11-1
- ¹⁰ Arthur, P. F., Archer, J. A., Johnston, D. J., Herd, R. M., Richardson, E. C. and Parnell, P. F. 2000. Genetic and phenotypic variance and covariance components for feed intake, feed efficiency and other postweaning traits in Angus cattle. J. Anim. Sci. 79: 2805-2811.
- ¹¹ JR Wythes, SR McLennan and MA Toleman, Liveweight loss and recovery. Australian Journal of Experimental Agriculture and Animal Husbandry 20 (106) 517 - 52
- ¹² Galyean M.L. Perino, L. J. and Duff G. C. 1999 BOARD-INVITED REVIEW Interaction of cattle health/immunity and nutrition J Anim Sci. 77:1120-1134.
- ¹³ Sowell, B. F., M. E. Branine, J. G. P. Bowman, M. E. Hubbert, H. W. Sherwood, and W. F. Quimby. 1999. Feeding and watering behaviour of healthy and morbid steers. J. Anim. Sci. 77:1105–1112.
- ¹⁴ R. L. Larson, Effect of cattle disease on carcass traits J ANIM SCI June 2005 vol. 83 no. 13 suppl E37-E43
- ¹⁵ G/ Loneragan,, WTAMU, 2008 Sentinel Feedlot Monitoring Program (USDA:CEAH)
- ¹⁶ A. P. Kelly and E. D. Janzen 1986. A Review of Morbidity and Mortality Rates and Disease Occurrence in North American Feedlot Cattle, Can Vet J Volume 27.