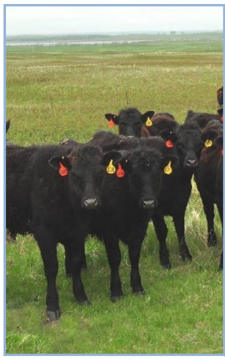

Utilizing an Electronic Feeder and Ear Tag Accelerometer to Measure Mineral and Energy Supplement Intake and Reproductive Behavior in Beef Heifers Grazing Native Range

Kacie L. McCarthy[1], Sarah R. Underdahl[1], Michael Undi[2], Stephanie Becker[2] and Carl R. Dahlen[1]
[1]Department of Animal Sciences, North Dakota State University, Fargo, N.D.
[2]Central Grasslands Research Extension Center, Streeter, N.D.

The objectives of this study were to develop a mobile cow command center (MCCC) to 1) examine the relationship between mineral and energy supplementation on intake and feeding behavior on native range and 2) examine reproductive behavior of heifers on native range utilizing the CowManager system. The MCCC paired two commercially available technologies - a SmartFeed device, which monitors intake, and a CowManager system, which monitors cow reproductive, feed-related and health -associated data - in a single trailer unit that can be transported and function anywhere cattle are managed.

Our results clearly show that the feed-controlling portion of the MCCC can be used for precision feeding of individuals in expansive group-managed scenarios. Further, the estrus and health alert functions of the CowManager system were found to be unreliable triggers for management responses that could lead producers to inappropriate conclusions about the status of their herds.

Summary

Crossbred Angus yearling heifers (n = 60) at the Central Grasslands Research Extension Center (Streeter, N.D.) were used to evaluate an electronic feeder and ear tag accelerometer to measure mineral and energy supplement intake and reproductive behavior in heifers grazing native range. Heifers were fitted with radio frequency identification (RFID) ear tags that allowed access to an electronic feeder (SmartFeed system; C-Lock Inc., Rapid City, S.D.) from which supplements were delivered.

Heifers were assigned randomly to one of three dietary treatments: 1) no access to feed supplements (**CON**; n = 20); 2) free-choice access to mineral supplement (**MIN**; Purina Wind and Rain Storm [Land O'Lakes Inc.], n = 20); or 3) free-choice access to energy supplement (**NRG**; Purina Accuration Range Supplement [Land O'Lakes Inc.], n = 20). Heifers also were fitted with a CowManager tag that uses the RFID tags and additional sensors to monitor cow reproductive (estrus alerts), feed-related (eating, rumination and activity level) and health-associated (body temperature) data.

Heifers were artificially inseminated utilizing sexed semen and turned out to graze at the initiation of the study. Consecutive weights were taken at the beginning and end of the study, along with blood and liver biopsy samples. Heifers in the NRG treatment (819.5 ± 85.0 grams per day [g/d]) consumed more ($P < 0.001$) energy supplement, compared with CON (3.7 ± 85.0 g/d) or MIN (0.5 ± 85.0 g/d) heifers.

We found no differences in initial liver mineral concentrations among treatments ($P > 0.50$). Final cobalt (Co) levels were lower in CON heifers, compared with MIN or NRG heifers; however, selenium (Se), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo) and manganese (Mn) were not different among treatments ($P > 0.13$). The MCCC units were deployed successfully and serve as portable units that use solar power to run individual feeders and upload data to cloud-based data acquisition platforms.

Introduction

As technology is advancing at an amazing rate, some sectors of agriculture are implementing new innovations with the utmost fervor. However, the beef industry is lagging behind other industries in the rate of adoption.

Several reasons likely exist for this adoption lag, foremost of which are the lack of comprehensive technological solutions that can be implemented in expansive pasture settings, and the lack of solutions from which management decisions can be made during the life of the individual. Each individual in a herd of cattle is unique, and differences can be found in variations in stage of production, specific nutritional needs and health status within herds.

These variations change throughout not only the production year, but the life cycle of the individual. Activities reported herein are aimed at pairing technologies to design and test a system that would allow for precision management of individuals within a herd to optimize production efficiency, improve animal health and enhance profitability.

This research explores the possibility of identifying and monitoring feed intake, estrus behavior and health status remotely while cattle are being managed in extensive pastures. This information could lead to targeted management strategies for cows with distinct nutrient needs (high and low body condition scores or mixed groups of cows and heifers) while being managed in common pastures. The project also contributes to the long-term goal of developing precision management strategies during the lifetime of cattle in our herds.

The concept of the mobile cow command center (MCCC) is to pair two commercially available technologies into a single trailer unit that can be transported and function anywhere cattle are managed. The two technologies are the SmartFeed device, which monitors intake, and the CowManager system, which uses RFID tags and additional sensors to monitor cow reproductive, feeding-related and health-associated data.

Therefore, our objectives were to develop a mobile cow command center (MCCC) for 1) examining the relationship between mineral and energy supplementation on intake and feeding behavior on native range and 2) examining reproductive behavior of heifers on native range utilizing the CowManager system.

Procedures

All animal procedures were conducted in accordance with the rules of the Institutional Animal Care and Use Committee at North Dakota State University.

Mobile Cow Command Center Units

Two MCCCs were developed by pairing two commercially available technologies into single-trailer units that can be transported and function anywhere cattle are managed. The first technology is the SmartFeed device (C-lock Inc., Rapid City, S.D.; see www.c-lockinc.com), which is a self-contained system designed to measure supplement intake and feeding behavior from individual cattle in group settings.

The system is solar powered and includes a radio frequency identification (RFID) reader, weigh scales, access control gate, a feed bin and a cloud-based interface that continuously logs feed intake and feeding behavior data.

The second technology in the MCCC was the CowManager system (distributed by Select Sires in the U.S.; see www.cowmanager.com/en-us), which uses RFID tags and additional sensors to monitor cow reproductive (estrus alerts), feeding-related (eating, rumination and activity level) and health-associated (body temperature) data.

Data were received by a router attached to a computer in each MCCC that automatically uploaded the data for viewing on any device with an internet connection. Two SmartFeed units and controlling hardware and the CowManager systems were placed in each of two enclosed trailers with open feed-access areas and retractable wheels for easy transport.

Training Period

One hundred twenty-six crossbred yearling Angus heifers were managed for two weeks in dry lots at the Central Grasslands Research Extension Center (CGREC). Heifers were split into two pens (n = 63), where they all were given access to one SmartFeed trailer.

Each trailer contained two SmartFeed units that provided corn silage in each of the feed bins. The units were set at training mode, which locked the gate in the lowest position to allow easy access to feed in the bins. The radio frequency identification (RFID) reader and antenna recorded heifer RFID and intakes during the training period.

Heifer Selection

All heifers were estrus synchronized using a controlled internal drug release (CIDR; Zoetis) protocol, with heifers receiving 2 cc of GnRH (Factrel; Zoetis, Parsippany, N.J.) intramuscularly and a CIDR insert on day zero. Seven days later, the CIDR insert was removed and a single injection of $PGF_{2\alpha}$ (5 cc intramuscularly; Lutalyse; Zoetis, Parsippany, N.J.) was administered, followed by GnRH and artificial insemination approximately 60 hours later (seven-day CO-Synch plus CIDR protocol).

All heifers received an Estrotect patch to determine heat state. On the day of artificial insemination (AI), heifers were selected on the following basis: 1) patch score, 2) classification as “eater” or not and 3) exposure to feeders as calves on a previous study. All MCCC heifers (n = 60) were AI bred using sexed semen (Tehama Tahoe B767) and pregnancy checked via rectal ultrasonography (7.0-MHz transducer, 500 V Aloka, Wallingford, Conn.) 34 days after AI.

Grazing Period

Sixty crossbred yearling Angus heifers were managed as a single pasture group with free access to native range grazing at the Central Grasslands Research Extension Center (CGREC). Heifers were assigned randomly to one of three dietary treatments: 1) no access to feed supplements (**CON;** n = 20); 2) free-choice access to mineral supplement (**MIN**; Purina Wind and Rain Storm [Land O’Lakes Inc.], n = 20); or 3) free-choice access to energy supplement (**NRG**; Purina Accuration Range Supplement [Land O’Lakes Inc.], n = 20).

The MIN and NRG supplements were delivered via the MCCC SmartFeed units and only heifers assigned to the respective treatments were allowed access to the feeders through the web-based controlling interface. Feed intake data were summarized from the time of MCCC deployment (July 25, 2018) until removal from pasture (Sept. 19, 2018; Figure 1). The relationship between supplement intake reported with the SmartFeed units and activity reported with the CowManager system was evaluated during the 57-day period when heifers were actively consuming supplements (July 25 to Sept. 19, 2018).

Estrus-related events were generated via the CowManager system and were listed as in heat, potential or suspicious. Heifers were monitored for return to estrus after AI, and ultrasound was used to confirm pregnancies.

A retrospective analysis was conducted to determine the accuracy

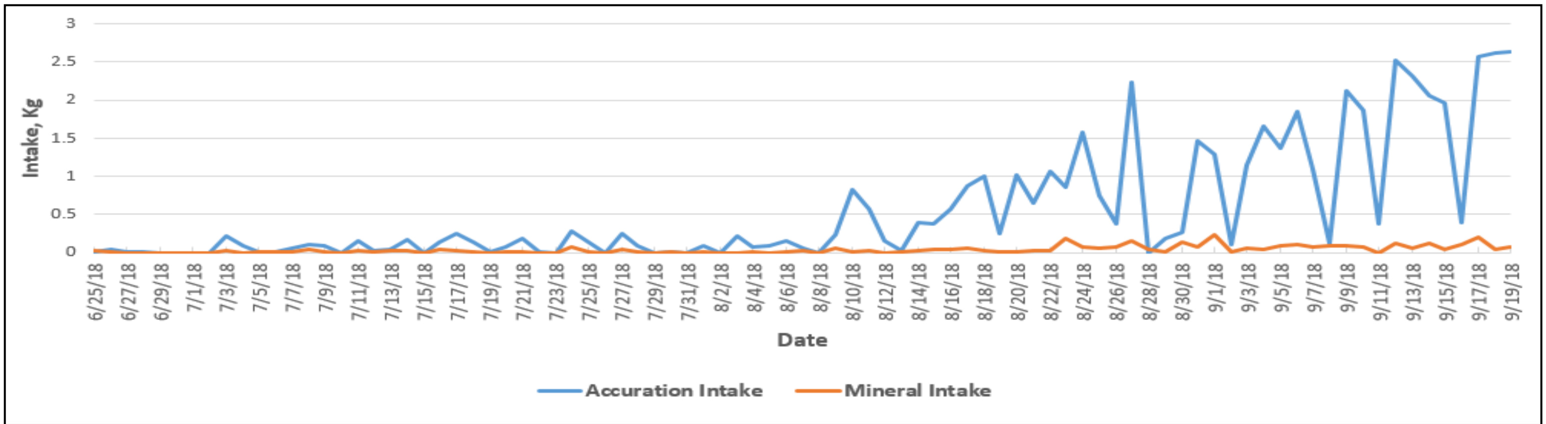

Figure 1. Intake of mineral and energy supplements during the grazing period.

of estrus-related alerts generated via the CowManager system versus a known pregnancy status. Similarly, a retrospective analysis was conducted to evaluate the accuracy of health events that were flagged via the CowManager system (reported as sick, very sick or no movement) by comparing with treatment logs generated by the animal care staff at the CGREC.

Samples of liver were collected on the first and final day of monitoring via biopsy from a subset of heifers from each respective treatment (n = 24; eight per treatment). Heifers were restrained in a squeeze chute and the hair between the 10th and 12th ribs was clipped.

Liver biopsy samples were collected using the method of Engle and Spears (2000) with the modification that all heifers were given an intradermal 3 milliliter (mL) injection of Lidocaine Injectable-2% (MWI, Boise, Idaho) at the target biopsy site. A stab incision then was made between the 10th and 11th intercostal space at an intersection with a line drawn horizontally from the greater trochanter. A core sample of liver was taken via the Tru-Cut biopsy trochar (14 g; Becton Dickenson Co., Franklin Lakes, N.J.).

After obtaining liver biopsies, a staple and topical antibiotic (Aluspray; Neogen Animal Safety, Lexington, Ky.) was applied to the surgical site and an injectable NSAID (Banamine; Merck Animal Health, Madison, N.J.) was administered. Biopsy samples were stored in vacuum tubes designed for trace mineral analysis (potassium EDTA; Becton Dickinson, Rutherford, N.J.) and stored at minus 20 C until further analysis. Liver samples were sent to the DCPAH at Michigan State University and were evaluated for concentrations of minerals using inductively coupled plasma mass spectrometry.

Analysis

Data were analyzed in SAS (9.4, SAS Inst. Inc., Cary, NC) for supplement intake, behavior and liver mineral concentrations via PROC GLM with significance at $P < 0.05$.

Results and Discussion

Intake of energy and mineral supplements was very low during the early portion of the grazing season but began to increase in mid-August as the quality of native range declined (Figure 1). From July 25, 2018, until Sept. 19, 2018, heifers in the MIN treatment (47.2 ± 3.4 g/d) consumed more ($P < 0.001$) mineral, compared with heifers in the CON (1.2 ± 3.4 g/d) and NRG treatments (2.1 ±3.4 g/d), and heifers in the NRG treatment (819.5 ± 85.0 g/d) consumed more ($P < 0.001$) energy supplement, compared with CON (3.7 ± 85.0 g/d) or MIN (0.5 ± 85.0 g/d) heifers.

Table 1. Activity of heifers monitored using CowManager ear tags.

	Treatment				
Parameter	**CON**	**MIN**	**NRG**	SE	*P*-Value
Eating, min/d	560.9	562.1	483.8	32.4	0.16
Ruminating, min/d	350.7	350.8	368.6	24.19	0.83
Not active, min/d	181.1	176.0	214.7	16.02	0.19
Active, min/d	210.7	212.2	214.1	29.33	0.99
Highly active, min/d	138.3^{x}	139.7^{x}	159.8^{y}	5.71	0.02

^{x,y} means with uncommon superscripts differ ($P = 0.01$).

Activity data from the CowManager tags indicate that time spent eating, ruminating, not active or active were not impacted by treatment ($P \geq 0.16$, Table 1). However, heifers in the NRG treatment spent 20 more ($P = 0.02$) minutes on a daily basis being highly active, compared with heifers in the other treatments (Table 1). The additional time NRG heifers spent being highly active likely was related to competition for energy supplements at feeders, where 20 heifers were competing for two feeding spaces. Interestingly, treatment did not impact weight gain ($P = 0.93$) during the monitoring period, with heifers gaining an average of 0.47 kilogram per day (kg/d).

Evaluation of estrus data revealed that 16 of 28 heifers confirmed pregnant via ultrasound (57 percent) were identified incorrectly as displaying estrus behavior (two reported as in heat, 11 reported as potential and three reported as suspicious). Additionally, 146 health alerts were generated, but only 13 heifers needed clinical treatment. An additional nine heifers required treatment but did not generate an alert.

We found no differences in initial liver mineral concentrations among treatments ($P > 0.50$; Table 2). Final Co levels were lower in CON heifers, compared with MIN or NRG heifers; however, Se, Fe, Cu, Zn, Mo and Mn were not different among treatments ($P > 0.13$).

According to Kincaid (2000), liver mineral concentrations for Fe, Zn, Mo and Mn are considered adequate for heifers among treatment groups. Adequate liver Cu concentrations are defined as 125 to 600 micrograms per gram (ug/g) dry matter (DM) (Kincaid, 2000) and normal is defined as greater than 100 ug/g DM (Radostits et al., 2007).

Therefore, heifers would be considered marginal (33 to 125 ug/g DM; Kincaid, 2000) to adequate or normal for liver Cu concentrations. Selenium concentrations in the liver for heifers were classified as adequate (1.25 to 2.50 ug/g DM; Kincaid, 2000).

Liver Co levels at 0.08 to 0.12 ug/g DM or more indicate satisfactory Co status (McNaught, 1948), and the heifers in this study were above satisfactory levels. Overall, heifers in their respective treatment groups had adequate liver mineral concentrations. In conclusion, the MCCC units were deployed successfully and serve as portable units that use solar power to run individual components and upload data to cloud-based data acquisition platforms. SmartFeed units were able to control the intake of individual animals assigned to different treatments in a group pasture scenario.

Our results clearly show that the feed-controlling portion of the MCCC can be used for precision feeding of individuals in expansive group-managed scenarios. The CowManager system was able to detect divergence in highly active behavior among treatment groups but also reported many false health and estrus-related alerts.

Table 2. Liver mineral concentrations of heifers grazing native range and provided access to a mineral or energy supplement.

	Treatment[1]				
Item	**CON**	**MIN**	**NRG**	**SE**	***P*-value**
Initial					
Co	0.22	0.20	0.21	0.01	0.53
Mn	9.46	9.13	9.70	0.63	0.82
Mo	3.26	3.16	3.51	0.22	0.52
Zn	130.63	118.27	138.88	12.73	0.52
Cu	162.88	137.90	155.98	28.66	0.82
Fe	299.01	299.88	307.16	21.70	0.96
Se	1.68	1.53	1.69	0.11	0.50
Final					
Co	0.131^{x}	0.303^{y}	0.29^{y}	0.04	0.01
Mn	9.73	8.89	9.80	0.65	0.55
Mo	3.73	3.87	3.62	0.22	0.71
Zn	101.90	100.75	107.74	6.84	0.74
Cu	82.72	99.55	92.25	16.79	0.78
Fe	191.12	211.99	258.48	23.10	0.13
Se	1.43	1.58	1.66	0.11	0.35

^{xy} Means differ at $P < 0.05$.

[1] Treatment: **CON**, no access to feed supplements; **MIN,** free-choice access to mineral supplement; or **NRG**, free-choice access to energy supplement.

Acknowledgments

The authors acknowledge the staff at the Central Grasslands Research Extension Center for assistance with animal handling and forage collection. The authors thank the North Dakota Agricultural Experiment Station Precision Agriculture Fund for partial support for this effort.

Literature Cited

Engle, T.E., and J.W. Spears. 2000. Effects of dietary copper concentration and source on performance and copper status of growing and finishing steers. Journal of Animal Science 78:2446-2451. doi: 10.2527/2000.7892446x

Kincaid, R.L. 2000. Assessment of trace mineral status of ruminants: A review. Journal of Animal Science 77 (suppl_E):1-10. doi: 10.2527/jas2000.77E-Suppl1x

McNaught, K.J. 1948. Cobalt, copper and iron in the liver in relation to cobalt deficiency ailment. New Zealand Journal of Science and Technology, Section A 30:26-43.

Radostits, O.M., C.C. Gay, K.W. Hinchcliff and P.D. Constable. 2007. Veterinary Medicine: A textbook of the diseases of cattle, horses, sheep, pigs, and goats. Saunders Elsevier.