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Utilizing an electronic feeder to measure mineral and energy supplement intake in beef heifers grazing native range

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INTRODUCTION

Grasslands in the Northern Plains provide the primary forage source for ruminants throughout much of the year (Schauer et al., 2004). Supplementation practices are often necessary to maintain production and offset forage nutritive decline throughout the grazing season (Schauer et al., 2004; Cline et al., 2009). Typically, to maintain a targeted production level, energy and protein supplementations are used for grazing livestock (Caton and Dhuyvetter, 1997). For developing heifers consuming low-quality forages, inclusion of energy ingredients into supplements may be beneficial for growth and reproductive performance (Schillo et al., 1992; Ciccioli et al., 2005; Cappellozza et al., 2014). In addition, the use of corn and distillers grains supplement has been compared to evaluate performance responses (Loy et al., 2007) but the influence of these strategies on intake and feeding behavior on pasture are lacking.

Moreover, supplementing mineral to cattle grazing poor-quality range vegetation can improve forage utilization and animal performance (Köster et al., 1996; Caton and Dhuyvetter, 1997). An issue with providing mineral supplements to cattle, however, is the degree of variability in intake, with some cattle over consuming or under consuming supplements (Tait and Fisher, 1996; Cockwill et al., 2000; Greene, 2000). However, providing supplements to pasture-based cattle does not allow measurements of individual animal mineral and supplement intake; as a result, mineral and supplement intake is measured on a group basis. The use of electronic monitoring systems in the beef industry has been limited to systems primarily used in research settings to examine the effects on feed intake in relation to cattle growth performance (Islas et al., 2014), daily intake of salt-limited supplements (Reuter et al., 2017), health status (Wolfger et al., 2015), or animal movement in extensive pasture settings (Schauer et al., 2005). These technologies could be adapted easily for the use in beef cattle production systems to monitor activity, feeding or drinking behavior, or as tools for monitoring inventories in intensive or extensive production systems. Therefore, our objectives were to examine the relationship between mineral and energy supplementations provided via an electronic feeder on intake, liver mineral concentrations, and metabolites in heifers being managed on native range.

MATERIALS AND METHODS

All animal procedures were conducted in accordance with the rules of the institutional animal care and use committee at North Dakota State University.

Electronic Feeders

The SmartFeed device (C-lock Inc., Rapid City, SD) is a self-contained system, designed to

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measure supplement intake and feeding behavior from individual cattle in group settings. The system is solar powered and includes a radio-frequency identification reader, weigh scales, access control gate, a stainless steel feed bin, and a cloud-based interface, which continuously logs feed intake and feeding behavior data. Two SmartFeed units were placed in each of two enclosed trailers with open feed access areas and retractable wheels for easy transport.

Grazing Period

Sixty crossbred yearling Angus heifers (initial body weight [BW] = 400.4 ± 6.2 kg) were selected from an initial group of heifers (n = 126) based on intake during a 14-d training period and previous exposure to the electronic feeders. Heifers were managed as a single pasture group with free access to native range grazing at the Central Grasslands Research Extension Center. The pasture was 70 ha with a stocking rate of 1.99 Animal Unit Months/ha. Heifers were randomly assigned to one of following three dietary treatments; 1) control (CON), no access to feed supplements (n = 20); 2) mineral (MIN), free choice access to mineral supplement (Purina Wind and Rain Storm [Land O'Lakes, Inc.], n = 20); or 3) energy (NRG), free choice access to energy supplement (Purina Accuration Range Supplement [Land O'Lakes, Inc.], n = 20). The NRG supplement was composed of corn, fish oil, and mineral (25.49% crude protein). The MIN and NRG supplements were delivered via the SmartFeed units and trailers were located next to the water source in the pasture. 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 mid-summer (July 25, 2018) until removal from pasture (September 19, 2018) over a 57-d monitoring period. After intakes were summarized, heifers assigned to treatments that did not consume any mineral or supplement were then assigned to control treatments. Performance and intake treatment adjustments included CON (n = 29), MIN (n = 18), and NRG (n = 13).

Blood samples were collected via jugular venipuncture into serum tubes (10 mL; Becton Dickinson Co., Franklin Lakes, NJ), cooled and centrifuged at 1,500 × g at 4 °C for 20 min. Serum was separated and stored in plastic vials at −20 °C until further analysis. Serum samples were analyzed for glucose and non-esterified fatty acid (NEFA). Samples were analyzed using the Synergy H1 Microplate Reader (Biotek, Winooski, VT) with the Infinity Glucose Hexokinase Kit (Thermo Scientific, Waltham, MA) and NEFA-C Kit (WAKO Chemicals, Inc., Richmond, VA). The intra- and interassay coefficient of variation was 2.62% and 3.41%, for serum glucose, respectively, and 7.75% and 8.29%, for serum NEFA, respectively.

Samples of liver were collected at pasture turnout (d –34) and final day of monitoring (d 57) via biopsy from a subset of heifers from each respective treatment (n = 24). Heifers were restrained in a squeeze chute and the hair was clipped between the 10th and 12th ribs. Liver biopsy samples were collected using the method of Engle and Spears (2000). A stab incision was then made between the 11th and 12th intercostal space at an intersection with a line drawn horizontally from the greater trochanter. A core sample of the liver was taken via the Tru-Cut biopsy trochar (14 g; Becton Dickinson Co., Franklin Lakes, NJ). After obtaining liver biopsies, a staple and topical antibiotic (Aluspray; Neogen Animal Safety, Lexington, KY) was applied to the surgical site and an injectable nonsteroidal anti-inflammatory drug (Banamine; Merck Animal Health, Madison, NJ) was administered. Biopsy samples were stored in vacuum tubes designed for trace mineral analysis (potassium ethylenediaminetetraacetate; Becton Dickinson Co., Franklin Lakes, NJ) and stored at –20 °C until further analysis. Liver samples were sent to the Diagnostic Center for Population and Animal Health at Michigan State University and were evaluated for concentrations of minerals using inductively coupled plasma mass spectrometry.

Analysis

Data were analyzed as a completely randomized design with heifer used as the experimental unit for all intakes, liver, and metabolite concentrations. All data were analyzed using the general linear model procedure of SAS (9.4, SAS Inst. Inc., Cary, NC) with treatment as the fixed effect. Data were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

Overall, heifer final BW was similar among treatments (432.5 ± 5.9 kg; P = 0.92). Interestingly, treatment did not affect weight gain (P = 0.76) over the monitoring period, with heifer average daily gain equal to 0.46 kg/d.

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. From July 25, 2018 to September 19, 2018, heifers in the MIN treatment

(49.3 ±3.5 g/d) consumed more ($P < 0.001$) mineral compared with heifers in the CON (2.7 ± 3.5 g/d) and NRG treatments (2.1 ±3.5 g/d). Heifers in the NRG treatment (1,249.3 ± 36.4 g/d) ate more ($P < 0.001$) energy supplement compared with CON (6.7 ± 36.4 g/d) or MIN (0.2 ± 36.4 g/d) heifers.

There were no differences ($P > 0.10$; Table 1) in serum NEFA concentrations among treatment groups at d –34 and 57. Serum glucose was similar ($P = 0.77$) among treatments at d –34. However, glucose levels were greater ($P = 0.03$) in NRG heifers compared to CON and MIN heifers at d 57. In ruminants, starch is a major dietary precursor for glucose (Huntington, 1997); hence, it would be expected that NRG heifers had greater glucose levels compared to CON and MIN heifers. Similar NEFA and glucose concentrations have been reported in heifers grazing low-quality forage and provided an energy supplement (Cappellozza et al., 2014).

Liver mineral concentrations at d –34 were not different among treatments ($P > 0.13$; Table 2). Liver mineral concentrations at d 57 for Cu, Zn,

Table 1. Effects of mineral and mineral with energy supplements on serum metabolite concentrations in heifers grazing native range

	Treatment[1]				
Measurement	CON	MIN	NRG	SE	*P*-value
Serum metabolites					
NEFA, µmol/L					
d –34[2]	457.34	625.99	616.65	63.37	0.10
d 57[3]	333.77	321.45	287.63	45.08	0.77
Glucose, mg/dL					
d –34	64.38	63.99	60.82	3.66	0.77
d 57	66.97[a]	66.65[a]	75.22[b]	2.28	0.03

[a,b]Means differ at $P < 0.05$.

[1]Treatments include: CON ($n = 12$), no access to feed supplements; MIN ($n = 10$), free choice access to mineral supplement; NRG ($n = 8$), free choice access to energy supplement.

[2]Sample taken on d –34 at pasture turnout.

[3]Sample taken on final d of monitoring period (d 57).

Table 2. Effects of mineral and mineral with energy supplement on liver mineral concentrations in heifers grazing native range

	Treatment[1]				
Item	CON	MIN	NRG	SE	*P*-value
d –34[2]					
Se	1.61	1.58	1.77	0.11	0.53
Fe	297.15	297.99	318.60	22.58	0.79
Cu	151.75	144.41	164.44	30.26	0.91
Zn	123.05	122.23	154.01	12.82	0.22
Mo	3.12	3.29	3.77	0.21	0.13
Mn	9.33	9.31	9.85	0.66	0.84
Co	0.21	0.21	0.22	0.01	0.74
d 57[3]					
Se	1.39[a]	1.59[ab]	1.88[b]	0.09	0.008
Fe	197.56[a]	212.87[ab]	286.39[b]	22.95	0.04
Cu	75.12	103.44	114.15	16.54	0.21
Zn	98.93	102.32	115.95	6.8	0.24
Mo	3.57	3.92	3.90	0.22	0.39
Mn	9.24	8.98	10.72	0.66	0.22
Co	0.129[a]	0.317[b]	0.414[c]	0.018	<0.001

[abc]Means differ at $P < 0.05$.

[1]Treatments include: CON ($n = 10$), no access to feed supplements; MIN ($n = 8$), free choice access to mineral supplement; NRG ($n = 6$), free choice access to energy supplement.

[2]Sample taken on d –34 at pasture turnout.

[3]Sample taken on final d of monitoring period (d 57).

Mo, and Mn were not different among treatments ($P > 0.21$), however, Se was greater in NRG heifers compared to CON and MIN heifers ($P = 0.008$). Iron concentrations were greater in NRG heifers compared to CON and MIN heifers ($P = 0.04$). The NRG heifers had the highest concentrations of Co, then MIN heifers followed by lower concentrations in CON heifers ($P < 0.001$).

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 µg/g DM (Kincaid, 2000) or normal > 100 µg/g DM (Radostits et al., 2007). Therefore, heifers would be considered marginal (33 to 125 µg/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 µg/g DM; Kincaid, 2000). Liver Co levels at 0.08 to 0.12 µg/g DM or more indicate satisfactory Co status (McNaught, 1948), which heifers were above satisfactory levels. Heifer liver mineral concentrations are lower than cows that were monitored the previous year with the same electronic feeders (McCarthy et al., 2018). Overall, heifers in their respective treatment groups had adequate liver mineral concentrations.

IMPLICATIONS

The SmartFeed units were able to control intake of individual animals assigned to different treatments in a group pasture scenario. Our results clearly show that the feed controlling portion of the SmartFeed units can be used for precision feeding of individuals in expansive group managed scenarios.

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Conflict of interest statement. None declared.

LITERATURE CITED

Cappellozza, B. I., R. F. Cooke, M. M. Reis, P. Moriel, D. H. Keisler, and D. W. Bohnert. 2014. Supplementation based on protein or energy ingredients to beef cattle consuming low-quality cool-season forages: II. performance, reproductive, and metabolic responses of replacement heifers. J. Anim. Sci. 92:2725–2734. doi:10.2527/jas.2013-7442.

Caton, J. S., and D. V. Dhuyvetter. 1997. Influence of energy supplementation on grazing ruminants: requirements and responses. J. Anim. Sci. 75:533–542. doi:10.2527/1997.752533x.

Ciccioli, N. H., S. L. Charles-Edwards, C. Floyd, R. P. Wettemann, H. T. Purvis, K. S. Lusby, G. W. Horn, and D. L. Lalman. 2005. Incidence of puberty in beef heifers fed high- or low-starch diets for different periods before breeding. J. Anim. Sci. 83:2653–2662. doi:10.2527/2005.83112653x.

Cline, H. J., B. W. Neville, G. P. Lardy, and J. S. Caton. 2009. Influence of advancing season on dietary composition, intake, site of digestion, and microbial efficiency in beef steers grazing a native range in western north dakota. J. Anim. Sci. 87:375–383. doi:10.2527/jas.2007-0833.

Cockwill, C. L., T. A. McAllister, M. E. Olson, D. N. Milligan, B. J. Ralston, C. Huisma, and R. K. Hand. 2000. Individual intake of mineral and molasses supplements by cows, heifers and calves. Can. J. Anim. Sci. 80:681–690. doi:10.4141/A99-120

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. J. Anim. Sci. 78:2446–2451. doi:10.2527/2000.7892446x.

Greene, L. W. 2000. Designing mineral supplementation of forage programs for beef cattle. J. Anim. Sci. 77:1–9. doi:10.2527/jas2000.00218812007700ES0013x

Huntington, G. B. 1997. Starch utilization by ruminants: from basics to the bunk. J. Anim. Sci. 75:852–867. doi:10.2527/1997.753852x.

Islas, A., T. C. Gilbery, R. S. Goulart, C. R. Dahlen, M. L. Bauer, and K. C. Swanson. 2014. Influence of supplementation with corn dried distillers grains plus solubles to growing calves fed medium-quality hay on growth performance and feeding behavior. J. Anim. Sci. 92:705–711. doi:10.2527/jas.2013-7067.

Kincaid, R. L. 2000. Assessment of trace mineral status of ruminants: a review. J. Anim. Sci. 77 (Suppl.E):1–10. doi:10.2527/jas2000.77E-Suppl1x

Köster, H. H., R. C. Cochran, E. C. Titgemeyer, E. S. Vanzant, I. Abdelgadir, and G. St-Jean. 1996. Effect of increasing degradable intake protein on intake and digestion of low-quality, tallgrass-prairie forage by beef cows. J. Anim. Sci. 74:2473–2481. doi:10.2527/1996.74102473x.

Loy, T. W., J. C. MacDonald, T. J. Klopfenstein, and G. E. Erickson. 2007. Effect of distillers grains or corn supplementation frequency on forage intake and digestibility. J. Anim. Sci. 85:2625–2630. doi:10.2527/jas.2005-750.

McCarthy, K. L., M. Undi, and C. R. Dahlen. 2018. Mineral intake, feeding behavior, and growth performance of cow-calf pairs grazing native range. J. Anim. Sci. 96(Suppl.2):83–84. doi:10.1093/jas/sky073.155

McNaught, K. J. 1948. Cobalt, copper and iron in the liver in relation to cobalt deficiency ailment. N. Z. J. Sci. Technol. 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. Philadelphia (PA): Saunders Elsevier.

Reuter, R. R., C. A. Moffet, G. W. Horn, S. Zimmerman, and M. Billars. 2017. Technical note: daily variation in intake of a salt-limited supplement by grazing steers. Prof. Anim. Sci. 33:372–377. doi:10.15232/pas.2016-01577

Schauer, C. S., D. W. Bohnert, D. C. Ganskopp, C. J. Richards, and S. J. Falck. 2005. Influence of protein supplementation frequency on cows consuming low-quality forage: performance, grazing behavior, and variation in supplement intake. J. Anim. Sci. 83:1715–1725. doi:10.2527/2005.8371715x.

Schauer, C. S., G. P. Lardy, W. D. Slanger, M. L. Bauer, and K. K. Sedivec. 2004. Self-limiting supplements fed to cattle grazing native mixed-grass prairie in the northern great plains. J. Anim. Sci. 82:298–306. doi:10.2527/2004.821298x.

Schillo, K. K., J. B. Hall, and S. M. Hileman. 1992. Effects of nutrition and season on the onset of puberty in the beef heifer. J. Anim. Sci. 70:3994–4005. doi:10.2527/1992.70123994x.

Tait, R. M., and L. J. Fisher. 1996. Variability in individual animal's intake of minerals offered free-choice to grazing ruminants. Anim. Feed Sci. Technol. 62:69–76. doi:10.1016/S0377-8401(96)01007-3

Wolfger, B., E. Timsit, E. A. Pajor, N. Cook, H. W. Barkema, and K. Orsel. 2015. Technical note: accuracy of an ear tag-attached accelerometer to monitor rumination and feeding behavior in feedlot cattle. J. Anim. Sci. 93:3164–3168. doi:10.2527/jas.2014-8802