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Summary

Past data from our laboratory showed water sulfate levels of 3,000 ppm reduced performance and health of growing steers during the summer. This experiment, conducted at the South Dakota State University Cottonwood Research Station, evaluated the effects of high sulfate water on cow and calf performance, milk production, and cow reproduction. Ninety-six crossbred, lactating cows (ages 2-13; average calving date of May 1) and their calves were assigned, after stratifying by age, weight, and previous winter management, to one of six pastures (16 cows/pasture) from June 3 to August 26, 2003. Pastures were randomly assigned to one of two water sulfate levels (three pastures/level). Treatments were low sulfate water (LS; average 388 ± 17 ppm sulfates) or high sulfate water (HS; average 2,608 ± 408 ppm sulfates). The HS water was created by adding sodium sulfate to the LS water. Cow 12-hour milk production was estimated by the weigh-suckle-weigh method at the initiation of the trial and again on July 2 and July 29. Initial milk production estimates were used to adjust the July 2 and July 29 estimates, which represented an average of 64 and 91 days into lactation, respectively. Cows on LS gained 15 lb and cows on HS lost 36 lb during the experiment ($P = 0.04$). Cows on HS tended to loose more ($P = 0.10$) body condition than LS (-0.27 and -0.48 for LS and HS, respectively). Twelve-hour milk production did not differ on July 2 ($P = 0.33$; 10.6 and 9.5 lb for LS and HS, respectively) or July 29 ($P = 0.48$; 11.9 and 11.0 lb for LS and HS, respectively). Calf ADG did not differ ($P = 0.71$) between treatments. Pregnancy rates (55-d breeding season) were 98% and 94% for the LS and HS treatments, respectively ($P = 0.36$). Sulfate levels averaging 2,608 ppm in the drinking water of cow-calf pairs during the summer increased cow weight loss and condition loss but did not reduce calf performance or reproduction compared to sulfate levels averaging 388 ppm.

Introduction

Water available to livestock in South Dakota and the surrounding region can be high in sulfates (Gould et al., 2002). We previously reported that water with 3,000 ppm sulfates or greater reduced ADG, DMI, water intake, and gain/feed of growing steers in confinement compared to water with approximately 400 ppm sulfates (Patterson et al., 2003). Additional work published in this report showed a decline in ADG, DMI, and gain/feed as sulfates in water for confined steers increased from approximately 400 to 4,700 ppm (Patterson et al., 2004). In the work of Patterson et al. (2004), we documented a 48% incidence of polioencephalomalacia (**PEM**) in confined steers receiving 4,700-ppm sulfate water during the summer. Research also showed water provided to steers grazing native range during the summer with 3,900 ppm sulfate or greater decreased ADG, but performance reductions were not as pronounced as with the confined cattle and few health problems were observed (Johnson et al., 2004).

Grazing steers may not be as sensitive to sulfates in the water as are those in confinement (on a dry ration) due to: 1) less heat stress in pasture cattle, 2) ingestion of water in grazed forages, 3) the ability of pasture cattle to consume standing water following precipitation events, and 4) other digestive or behavioral differences. We hypothesized that the lactating cow and her calf would be highly sensitive to water sulfates due to the correlation between milk production and water intake (NRC, 1996). Since cow-calf production is the major livestock enterprise in South Dakota, the impacts of sulfates in water on both the cow and the calf are important to document. Therefore, the objective of this study was to evaluate the effects of sulfates in water for cow-calf pairs grazing native range during the summer on cow

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and calf performance, milk production, and cow reproduction.

Materials and Methods

The study was conducted from June 3 to August 26, 2003 at South Dakota State University's Cottonwood Range and Livestock Research Station, near Philip, SD. Ninety-six crossbred, lactating cows (ages 2-13 yr; 1,394 lb) and their calves (average birth date May 1; ages 15–62 days; 174 lb) were assigned, after stratifying by age, weight, and previous winter management, to one of six pastures (16 cows/pasture). Pastures were randomly assigned to one of two water sulfate levels (three pastures/level). Treatments were low sulfate (**LS**) water or high sulfate (**HS**) water. Water was provided daily in aluminum stock tanks (round tanks; approximately 98 inches in diameter). The LS water was from a rural water system, and the HS water was created by adding sodium sulfate to LS water to target 3,000 ppm sulfate. The LS water was added to tanks daily and sodium sulfate was mixed directly into the stock tanks in the three HS pastures. Samples were taken daily from each HS pasture and from one LS pasture. Water samples were composited weekly and sent to the Water Resource Institute in Brookings, SD for sulfate analysis. Compiling all weekly composite sample results revealed the LS water averaged (± standard deviation) 388 ± 17 ppm sulfates, and the HS treatment averaged 2,608 ± 408 ppm sulfates. The volume of water added to tanks (for calculation of sodium sulfate addition to HS) and the volume of water consumed was calculated from the change in water depth and the tank surface area. Water consumption was adjusted for evaporation and precipitation (evaporation and precipitation measurements taken from a weather station located near the research pastures).

On June 3 (trial initiation) and August 26 (trial termination), both cows and calves were weighed and cows were assigned a body condition score (**BCS**; 1-9 scale; Richards et al., 1986) by two trained technicians (to the nearest 0.5 of a BCS). Cow-calf pairs were all on LS water and grazed native range prior to trial initiation. Cows were not allowed access to feed or water for approximately 12 hours prior to initial weight measurements. At the end of the trial, all cows and calves were placed on LS water for three days prior to final weight measurements. Cows and calves were separated and housed in a drylot without access to feed or water for approximately 12 hours prior to final weight measurements.

Once pasture assignments were made, cow-calf pairs were stratified by calving date within pasture group, and seven pairs/pasture (21/treatment) were selected to be used to estimate milk production (age of calves selected was between 18 and 43 days at trial initiation). Twelve-hour milk production was estimated by the weigh-suckle-weigh method (Boggs et al., 1980) on June 4 (initial), July 2, and July 29. Calves were separated from cows at approximately 8:00 am the day prior to measurements. Calves were returned to dams at 6:00 pm, allowed to suckle until content, and again removed. Calves were weighed the following morning at 6:00 am, returned to dams and allowed to suckle until content, and then weighed again. The difference in calf weight prior to and post-suckling was used as an estimate of 12-hour milk production. Data were not collected from seven calves on the LS treatment for both the July 3 and July 29 dates for reasons unrelated to treatment (n = 14 for LS treatment for those dates).

One yearling bull was turned into each pasture on July 4. Bulls were rotated between pastures within treatment on July 29, and all bulls were removed on August 28. Pregnancy was determined by rectal ultrasonagraphy in October of 2003.

Cow and calf weight, cow body condition score, and water intake data were analyzed by ANOVA in PROC GLM of SAS (SAS Inst. Inc., Cary, NC) with pasture as the experimental unit. Twelve-hour milk production data from July 2 and July 29 were analyzed (animal as experimental unit) using initial measurements taken June 3 as a covariate (an adjustment to subsequent estimates). Cow pregnancy rates were analyzed by Chi-Square in PROC GENMOD of SAS, with pasture as the observation and animal as the event within observation.

Results and Discussion

Seven cows-calf pairs from one of the LS pasture groups were removed from the study for reasons unrelated to treatment. An additional cow from another LS pasture died of a suspected lighting strike, and one cow from the third LS pasture group was removed from the data set due to suspected hardware disease. One cow and one calf (each in a different pasture) from the HS treatment died with no cause of death determined. No evidence existed to suggest the deaths in the HS treatment were or were not associated with treatment. No PEM was diagnosed in this trial.

Water intake across all pastures averaged 19.8 gallons/cow-calf pair with no differences (P = 0.94) between treatments (Table 1). Cows on LS gained 15 lb and cows on HS lost 36 lb during the 84-d experiment (P = 0.04; Table 1). In addition, cows on HS lost 0.21 of a BCS more (P = 0.10) during the experiment than LS cows, and HS cows had a lower BCS at trial end than LS cows (P = 0.04). Calves, on average, weighed 175 lb at trial initiation and 373 lb at trial termination, with no differences ($P > 0.05$) between treatment in calf weights or calf average daily gain (Table 1). Twelve-hour milk production did not differ between treatments on July 2 or July 29 ($P > 0.30$), and averaged (across treatments) 10.1 and 11.5 lb for July 2 and July 29, respectively (Table 2). Pregnancy rates, measured by rectal ultrasonography in October, were 98% and 94% for the LS and HS treatments, respectively (P = 0.36).

Previous research showed reductions in water intake of steers in the feedlot when the water contained elevated sulfate levels (Patterson et al., 2003; 2004). We did not observe differences in water intake in this study, despite a relatively low variation in the data (Table 1). The lack of difference in water intake may help explain the absence of a treatment effect on milk production and calf gain but does not explain differences in cow performance. Additional work published in this report (Johnson et al., 2004) showed an 11% reduction in ADG of foraging steers receiving water containing 3,947 versus 404 ppm sulfates without differences in water intake. Nevertheless, foraging steers receiving water with 4,654 versus 441 ppm sulfates had a 13% reduction in water intake and a 32% reduction in ADG (Johnson et al., 2004). High levels of sulfur intake, independent of water intake, may have negative impacts on performance of cattle (Zinn et al., 1997). The impacts of the high sulfates in water on cow performance in this study were pronounced, but calf performance was not affected. Apparently, HS cows sacrificed body condition to sustain milk production.

The current study did not document high rates of PEM in the high sulfate treatments (one cow and one calf died in the HS treatment with no cause of death determined), which is unlike our work with growing steers in the feedlot (Patterson et al., 2003; 2004). Patterson et al. (2003) reported a 15% incidence of PEM, with a 5% mortality rate, when confined steers were provided with water that averaged approximately 3,000 ppm sulfates (slightly higher than this study). Working with feedlot cattle, Loneragan et al. (2001) reported reduced gain but no PEM with water sulfates levels up to 2,360 ppm.

There are a few important points to consider when interpreting results of this study. The treatment period occurred during the summer months when high sulfate water issues are of greatest concern (Patterson and Johnson, 2004). This study does not, however, evaluate the effects of water high in sulfates supplied during late gestation or late lactation on calf gain and reproduction. This study was conducted, on average, from one to four months post-calving. At four to six months post-calving, calves would be expected to consume less milk (as a % of BW) and more water, which could make them more directly affected by water sulfates. We targeted a sulfate level of 3,000 ppm in the HS treatment, but we actually achieved an average of 2,608 $\pm$ 408 ppm sulfates. Inference should not be drawn to sulfate levels greater than our reported average. We have documented that a threshold for cattle tolerance to water sulfates does indeed exist (Patterson et al., 2004). Finally, the bull to cow ratio used in this study was approximately 1:15. Lower bull to cow ratios could potentially impact reproduction in high sulfate situations.

We conclude that water provided to early-lactating cow-calf pairs averaging 2,608 ppm in sulfates reduced cow weight and tended to reduce body condition change compared to water averaging 388 ppm sulfates. Milk production, calf average daily gain, and cow pregnancy rates were not affected by treatment.

Implications

Calf gain and cow reproduction were not impacted when grazing cows received drinking water averaging approximately 2,600 ppm sulfates from one to four months of lactation. Cows on high sulfate water lost more body weight and condition during the summer. The impacts of the body condition score loss on subsequent reproduction would be dependent on initial body condition score and cow management the following winter. More work is needed to determine critical sulfate levels in the drinking water for cow-calf pairs.

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Tables

Table 1. Performance and water intake of cow-calf pairs grazing native range and supplied water with low sulfates (average 388 ppm) or high sulfates (average 2,608 ppm) during the summer (Least Squares Means)[a]

	Treatment		
Item	Low Sulfate (LS)	High Sulfate (HS)	SEM
Cow initial weight, lb	1,396	1,392	17
Cow final weight, lb	1,411	1,356	27
Cow weight change, lb	15[b]	-36[c]	12
Cow initial body condition score	6.00	5.91	0.05
Cow final body condition score	5.73[b]	5.43[c]	0.06
Cow body condition score change	-0.27[d]	-0.48[e]	0.07
Calf initial weight, lb	171	178	3
Calf final weight, lb	367	379	10
Calf weight change, lb	196	201	8
Calf ADG, lb/d	2.34	2.39	0.10
Water Intake, gallons/d	19.77	19.81	0.36

[a]Trial lasted from June 3 to August 26, 2003 (84 days); Average calving date of May 1.
[b,c]Within a row, means with unlike superscripts differ (P = 0.04).
[d,e]Within a row, means with unlike superscripts differ (P = 0.10).

Table 2. Estimates of twelve-hour milk production for two dates using the weigh-suckle-weigh method for cow-calf pairs grazing native range and supplied water with low sulfates (average 388 ppm) or high sulfates (average 2,608 ppm) during the summer (Least Squares Means ± SEM)[a]

	Treatment	
Item	Low Sulfate (LS)[b]	High Sulfate (HS)[c]
July 3, 2003, lb	10.6 ± 0.8	9.5 ± 0.7
July 29, 2003, lb	11.9 ± 1.1	11.0 ± 0.9

[a]Trial began June 3, and initial (June 3) estimate of milk production was used as a covariate. Covariate was significant for July 3 measurement ($P = 0.002$); Covariate was not significant for July 29 estimate ($P > 0.9$).
[b]n = 14 for each date.
[c]n = 21 for each date.