Response of Cow-calf Pairs to Water High in Sulfates[1]

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Summary

Data from our laboratory showed water sulfate levels of 3,000 ppm reduced performance and health of growing steers during summer months. In addition, water averaging 2,600 ppm in sulfates for cow-calf pairs had little impact on calf growth or milk production, but caused small reductions in cow BW and body condition score (BCS). This experiment was conducted to evaluate the effects of high sulfate water on cow and calf performance, milk production, and reproduction. Ninety-six crossbred, lactating cows (ages 2-13; average calving date of April 14) and their calves 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 (average 368 ± 19 ppm sulfates) or high sulfate (HS) water (average 3,045 ± 223 ppm sulfates). The HS water was created by adding sodium sulfate to the LS water. Cows grazed native range and received a conventional mineral supplement ad-libitum from June 3 to August 26, 2004. Water was provided in aluminum stock tanks. Cow 12-h milk production was estimated by the weigh-suckle-weigh method on August 7. Cows were synchronized with a single injection of prostaglandin and bred by natural service. There were no differences in cow weight or BCS change during the trial ($P > 0.15$). Twelve-hour milk production in August was higher ($P = 0.02$) for LS (9.0 lb) than HS (7.5 lb). Calf ADG tended to be higher ($P = 0.14$) for LS (2.56 lb/d) than HS (2.45 lb/d). The percentage of cows that became pregnant during the first 25 days of the breeding season was higher ($P = 0.06$) for LS (81%) than HS (64%), and final pregnancy rates (55-d breeding season) were 92% and 83%, respectively ($P = 0.20$). Sulfate levels averaging 3,045 mg/L in the drinking water of cow-calf pairs during the summer reduced cow milk production and the number of cows bred early in the breeding season.

Introduction

Our research group continues to evaluate the effects of high sulfate water on cattle, with a goal of defining critical levels of total dissolved solids (TDS) and sulfates in the drinking water. Patterson et al. (2002) 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. Additional work showed a quadratic 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., 2003). These reports also showed that cattle in confinement consuming water with 3,000 ppm sulfates or greater were at a higher risk of polioencephalomalacia (**PEM;** Patterson et al. 2002; 2003). Based on these studies, we have concluded that the critical level of sulfates in the water for growing cattle during the summer months is 3,000 ppm. Since water requirements increase with elevated temperatures (NRC, 1996), this critical level may be different in various environments.

Johnson and Patterson (2004) reported that water with 3,941 ppm sulfates or greater reduced performance of grazing stocker steers in South Dakota. Few health problems were observed in stocker cattle receiving the high sulfate water over that two-year study. In addition, intermediate levels of sulfates were not tested, so a “critical” level could not be determined. Patterson et al. (2004) reported that water averaging 2,600 ppm sulfates for cow-calf pairs resulted in reduced cow weights but had little impact on reproduction or calf growth. The objective of this study was to evaluate the effects of sulfates in water averaging 3,000 ppm for cow-calf pairs grazing

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native range during the summer on cow and calf performance, milk production, and cow reproduction.

Materials and Methods

The study was conducted from June 3 to August 26, 2004 at South Dakota State University's Cottonwood Range and Livestock Research Station, near Philip, SD. Ninety-six crossbred, lactating cows (ages 2-13 yr; 1281 lb) and their calves (average birth date April 14; ages 18–80 days; 181 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 a targeted 3,000 ppm sulfate level. LS water was added to two storage tanks (one provided water for two HS pastures and one provided water for the remaining HS pasture). Sodium sulfate was added to LS water in the storage tanks during the afternoon of each day. Stock tanks were filled the following morning with either LS water or the previously-mixed HS water from the storage tanks. Samples from each water source were taken as stock tanks were being filled. Water samples were composited weekly and sent to the Water Resource Institute in Brookings, SD for sulfate analysis. A locally available commercial mineral was provided to cows in each pasture ad-libitum (13% Ca; 12% P; 13% salt; 2,000 ppm Cu; 8,000 ppm Zn).

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 and calves were separated and not allowed access to feed or water for approximately 12 h 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 h prior to final weight measurements.

On August 7, all cows were used to estimate twelve-hour milk production by the weigh-suckle-weigh method (Boggs et al., 1980). In brief, calves were separated from cows at approximately 0800 the day prior to measurements. Calves were returned to dams at 1800, allowed to suckle until content, and again removed. Calves were weighed the following morning at 0600, 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-h milk production. There were two calves in the LS group that did not suckle their dam, so their data were removed from analysis (LS: n = 46; HS: n = 48).

One two-year-old bull was turned into each pasture on July 2. On July 6, cows were given an injection of prostaglandin F_{2a} (25 mg i.m. ProstaMate, Phoenix, Scientific, Inc., St. Joseph, MO) to synchronize estrus. Bulls were rotated between pastures within treatment on July 29. Bulls were removed from pastures on August 26. Pregnancy was determined by rectal ultrasonagraphy 55 and 88 days following bull turnout. Pregnancies detected at 55 days were determined to be conceived in the first 25 d of the breeding season.

Water disappearance was measured by the daily change in water depth in the tank located in each pasture. This was adjusted for evaporation and precipitation using data collected at a weather station located near the experimental pastures.

Data were analyzed as completely randomized design. Cow and calf weight and cow body condition score 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 were analyzed by ANOVA with animal as the experimental unit. 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

Compiling all weekly water composite sample results revealed the LS water averaged 368 $\pm$ 19 ppm sulfates, and the HS treatment averaged 3,045 ± 223 ppm sulfates. The HS target of 3,000 ppm was achieved. Patterson et al. (2004) added sodium sulfate directly to stock tanks instead of storage tanks and reported that the target sulfate level of 3,000 ppm was not achieved (average 2,608 ± 408 ppm). Letting the water set in the storage tanks during the afternoon and overnight after mixing salts may have allowed more sulfates to go into solution in this experiment.

One cow from the HS treatment died two weeks prior to the end of the experiment. Diagnostics of brain tissue revealed no indication of PEM but did show high brain sodium levels.

Cow weight change from June 3 to August 26 was not different between treatments ($P = 0.17$; Table 1). In addition, both groups of cows maintained body condition over the experimental period ($P = 0.93$; Table 1). Patterson et al. (2004) showed that cows on 2,600 ppm sulfates had higher weight and body condition score loss over the summer than cows on 390 ppm sulfates. Calves in this study tended to have a lower ADG ($P = 0.14$) when the cow-calf pair was on HS water (Table 1), and the difference was supported by the HS cows having lower ($P = 0.02$) 12-h milk production than LS cows (Table 2). Patterson et al. (2004) did not report a significant effect of high sulfate water on calf performance or milk production. There was no difference in water disappearance (Table 1).

A higher ($P = 0.06$) percentage of cows on the LS treatment were bred in the first 25 days of the breeding season (81.3%) than were cows on the HS treatment (63.8%). This difference in early-season pregnancy could impact reproduction and weaning weights the following year. Overall pregnancy rates were not different ($P = 0.20$) between treatments (LS = 92%; HS = 83%).

It is not evident why results varied between this study and those reported by Patterson et al. (2004). The water in the current study was higher in sulfates and more consistent (narrower range) than Patterson el. (2004) reported. In addition, there were more two-year-old cows in the current study (34/96; 5-6/pasture) than in the former study (17/96; 2-3/pasture). Weather patterns and forage conditions are other possible reasons for differences between studies. Indeed, Johnson and Patterson (2004) reported a vegetation type by water quality interaction for ADG in yearling steers.

It is important to note that in the current study treatments were applied in a very specific and rather narrow time frame (one to four months post-calving). If the cattle were exposed to the HS water at different times, influences of physiological state and temperature may cause different responses. For example, 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. Finally, the bull to cow ratio used in this study was approximately 1:16. Lower bull to cow ratios could potentially impact reproduction in high sulfate situations.

We conclude that water provided to cow-calf pairs that averaged 3,045 ppm in sulfates reduced milk production, calf gains, and the percentage of cows bred early in the breeding season.

Implications

High sulfate water had negative impacts on reproduction and calf gains. Grazing cattle receiving high sulfate water may not have the degree of reduction in gain that cattle in confinement have. Additional work should address whether the effects of high sulfate water on reproduction are due to direct of effects of the water, induced trace mineral deficiencies, or both.

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Tables

Table 1. Performance of cow-calf pairs grazing native range and supplied water with low sulfates (average 368 ppm) or high sulfates (average 3,045 ppm) during the summer (Least Squares Means)[a]

	Treatment		
Item	Low Sulfate (LS)	High Sulfate (HS)	SEM
Cow initial weight, lb	1279	1283	16.8
Cow final weight, lb	1305	1290	21.0
Cow weight change, lb	26	9	17.4
Cow initial body condition score	5.54	5.46	0.088
Cow final body condition score	5.45	5.38	0.122
Cow body condition score change	-0.09	-0.08	0.059
Calf initial weight, lb	181	181	6.8
Calf final weight, lb	397	388	8.2
Calf ADG, lb/d	2.56[b]	2.45[c]	0.042
Water Disappearance, gallons/d	18.6	18.2	0.58

[a]Trial lasted from June 3 to August 26, 2004 (84 days); Average calving date of April 14.
[b,c]Within a row, means with unlike superscripts differ (P = 0.14).

Table 2. Estimates of twelve-hour milk production using the weigh-suckle-weigh method for cow-calf pairs grazing native range and supplied water with low sulfates (average 368 ppm) or high sulfates (average 3,045 ppm) during the summer (Least Squares Means ± SEM)[a]

	Treatment	
Item	Low Sulfate (LS)[a]	High Sulfate (HS)[b]
12-h Milk, lb	9.0 ± 0.49[c]	7.5 ± 0.46[d]

[a]n = 46.
[b]n = 48.
[c,d] Within a row, means with unlike superscripts differ (P = 0.02).