Effects of Water Quality on Performance and Health of Growing Steers

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Abstract

Water available to livestock in western South Dakota is often high in total dissolved solids (TDS) and sulfates. Eighty-one crossbred, yearling steers (700 lb) were used to determine the effects of TDS and/or sulfates in water on cattle performance and health. Cattle were stratified by weight and randomly assigned to one of 12 pens (6-7 steers/pen). Pens were randomly assigned to one of four treatments (three pens/treatment) based on supplied water: 1) rural water (RW; 1,019 ppm TDS; 404 ppm sulfates, 2) well water (WW; 4,835 ppm TDS; 3,087 ppm sulfates), 3) dam water (DW; 6,191 ppm TDS; 3,947 ppm sulfates), and 4) DW early switched to 10,000 ppm TDS water mid-summer (DWS). The DWS treatment was not achieved due to less than predicted TDS in dam water late in the summer, resulting in six pens in the DW treatment (three treatments). Dam water was transported from a local stock dam, and well water was pumped from a well on the research station. From June 20 to September 12, steers were fed a diet of grass hay and wheat middlings (NEg = 0.38 to 0.42 Mcal/lb), and the respective water was hauled into each pen. Water intake was lower ($P < 0.10$) for steers supplied WW (10.9 gallons/d) and DW (11.1 gallons/d) than for steers supplied RW (12.6 gallons/d). Steers supplied RW had higher DMI ($P < 0.10$) and gain/feed ($P < 0.05$) than steers supplied WW or DW. Steers supplied RW also had higher ADG ($P < 0.05$) than steers on WW or DW (1.38, 1.02, and 1.02 lb/day for RW, WW and DW, respectively). The incidence of polioencephalomalacia (PEM) was 15 and 12.5% for WW and DW, respectively, compared to no cases in RW ($P < 0.10$). Three steers died of PEM (one from WW and two from DW). Dietary sulfur concentrations were 0.27, 0.74, and 0.93% of dry matter for RW, WW and DW, respectively. It is unclear whether sulfur alone caused the reductions in performance or if other factors associated with TDS were important. Performance and health did not decline as TDS and sulfates increased above that in the WW treatment, indicating a threshold was achieved. Increased TDS and/or sulfates in the water reduced performance and health of growing steers.

Key words: Steers, Water, Performance, Sulfate, Polioencephalomalacia

Introduction

Water available to beef cattle in South Dakota is often high in total dissolved solids (**TDS**) and sulfates. Data from the USDA's National Animal Health Monitoring System (APHIS, 2000) showed samples collected in South Dakota feedlots averaged 2000 ppm TDS and over 1000 ppm sulfates. Data from our laboratory in 2000 and 2001 showed water samples collected from wells and stock dams in western South Dakota to have TDS as high as 15,000 ppm and sulfates as high as 10,000 ppm. The effects of this poor quality water on beef production have not been clearly documented, but high levels of dietary sulfur caused by ingestion of high sulfate water can cause polioencephalomalacia (**PEM**; McAllister et al., 1997). Sulfur induced PEM causes neurological disorder, gastrointestinal stasis, anorexia, blindness, and potentially death.

It is important to determine the effects of water quality on animal performance so that appropriate management practices can be developed. The objective of this study was to evaluate the effects of water from natural sources in western South Dakota that contained various levels of TDS and sulfates on the performance of growing steers during the summer.

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Materials and Methods

The study was conducted at South Dakota State University's Cottonwood Range and Livestock Research Station, near Phillip, SD. The experiment was conducted from June 20 to September 12, 2001. The average daily minimum and maximum temperatures during the study period were 59° and 91°F, respectively. Actual minimum and maximum temperatures were 41° and 108°F, respectively. Eighty-one crossbred steers (700 lb) were stratified by weight and randomly assigned to one of 12 pens (six-seven steers/pen). Pens were randomly assigned to one of four treatments (three pens/treatment) based on the quality of water supplied. Treatments were 1) rural water (**RW**), 2) well water (**WW**), 3) stock dam water (**DW**), and 4) DW early switched to extremely high sulfate DW late in the summer (**DWS**). Due to less than predicted TDS and sulfate in dam water late in the summer, the DWS treatment was not achieved. Therefore, there were six pens in the DW treatment (three total treatments).

The well water was pumped from a well on the research station, and dam water was transported from a local stock dam. The TDS and sulfate concentration the rural water and well water remained consistent throughout the summer, whereas the dam water increased in TDS and sulfates with advancing season (Table 1). Water was supplied in stock tanks to each pen. Water intake was measured by the change in daily water depth adjusted for evaporation and precipitation (measurements of evaporation and precipitation taken from a weather station located near the research feedlot). Depth measurements were converted to liters of water consumed using the surface area of each stock tank.

Steers were housed in dry-lot pens and fed a diet of grass hay (10.8% CP, 60.9% NDF) and pelleted wheat middlings. From June 20 to July 19, the diet consisted of 61% hay and 39% wheat middlings (DM basis; 14.3% CP, 0.38 Mcal/lb NEg, 0.19% S). Due to poorer-than-predicted performance, the ration was changed to 52.6% grass hay and 47.4% wheat middlings (14.9% CP, 0.42 Mcal/lb NEg, 0.19% S) on July 20, and remained constant throughout the rest of the experiment. We did not provide supplemental minerals so that impacts of water quality on the liver mineral stores could be evaluated (data not available to report at time of this publication). Salt was offered free choice at all times. Rations were fed once daily at 0800. Bunks were managed to be slick just prior to feed delivery, and any orts were weighed and recorded. Water samples were analyzed by the SDSU Water Resource Institute, Brookings SD. Feed samples were analyzed by Servi-Tech Laboratories, Hastings, NE.

Steer weights were taken in the morning on three consecutive days at the beginning and end of the experiment. Access to water was denied 12-h prior to weights. At the end of the experiment, all cattle were placed on RW and limit fed a constant amount of diet (approximately 2.0% of BW, DM basis) for 4 d prior to final weights. The 2.0% of BW level was chosen since it was less than that consumed by the pen with lowest intake prior to the final 4-d period. Steer ADG was calculated with dead cattle removed. Feed efficiency was calculated as ADG divided by average daily dry matter intake. Animal health was monitored daily. Cattle were diagnosed with PEM when showing clinical symptoms. Necropsies were performed on all mortalities by a licensed veterinarian, and tissue samples were submitted to the SDSU diagnostic laboratory for analysis.

Steer on-trial weight, off-trial weight, ADG, dry matter intake, feed efficiency, and water intake were analyzed as a completely randomized design in Proc GLM of SAS (SAS Inst. Inc., Cary, NC). Means were separated using the PDIFF option when the overall F-tests were significant *($P < 0.05$)*. Morbidity, mortality, and the incidence of PEM were analyzed with Chi-Square analysis in Proc GENMOD of SAS.

Results and Discussion

Steer gains (Table 2) were not as high as expected. Daily high temperatures averaged 90°F in the first 28 d of the experiment, and daily high temperatures reached 108°F by early August. Reduced feed intake, increased panting, and lethargy were observed on days with high maximum temperatures. The final weights of steers (Table 2) receiving WW and DW were 33 and 35 lb lighter, respectively, than steers receiving RW ($P < 0.05$). Average daily (Table 2) gains were 27% less for WW and DW treatments compared to RW ($P < 0.05$). Water intake (Table 2) was reduced in WW and DW treatments by 1.6 and 1.4 gallons, respectively, compared to RW ($P < 0.10$). Dry matter intake (Table 2) in WW and DW treatments was 6.2 and 5.0% less, respectively, than RW ($P < 0.10$). Feed efficiency, expressed as gain/feed (Table 2), was increased in RW steers compared to WW and DW ($P < 0.05$). There were no differences between the WW and DW treatments for any of the variables measured ($P > 0.50$).

Similar to results in this study, Loneragan et al. (2001) found linear reductions in ADG and feed efficiency of steers on a corn-based finishing ration when sulfates in water increased from 136 to 2,360 ppm. Weeth and Capps (1972) found a 12.4% reduction in hay intake when water sulfate levels were increased from 110 to 2,814 ppm, but water sulfate levels of 1,462 ppm did not impact intake. In the current study, water sulfate levels of 3,087 reduced dry matter intake, water intake, gain, and feed efficiency compared to 404 ppm sulfate water, but no further reductions were noticed when steers were supplied water containing 3,947 ppm sulfates. It appeared that a threshold was reached with the intermediate level of sulfates.

In the current study, there was no morbidity or mortality in the calves receiving RW, but calves on WW and DW experienced 25 and 15% morbidity, respectively (Table 3; $P < 0.05$). Most of the morbidity was associated with PEM, with WW and DW having a greater incidence than RW steers ($P < 0.10$). There were no differences in mortality ($P = 0.40$), but one steer from WW and two steers from DW died of PEM (confirmed by tissue analysis). One steer in the WW treatment experienced urinary calculi and died after termination of this experiment. It is not clear whether the urinary calculi was due to treatment. Since minerals were not supplemented, the Ca:P ratio was approximately 1:1 in this diet, which could potentially lead urinary calculi problems.

Daily sulfur intake was a likely cause of the PEM in cattle receiving WW and DW. The NRC (1996) gives the requirement and maximum tolerable level of sulfur to be 0.15 and 0.40% of DM intake, respectively. When accounting for sulfur in the water, dietary sulfur was 0.27, 0.74, and 0.93% of DM intake for RW, WW and DW, respectively. This resulted in an average intake of 22, 56, and 71 g/d of sulfur for RW, WW, and DW, respectively. Loneragan et al. (1998) found dietary levels of 0.9% sulfur (from feed) to be associated with PEM.

Implications

Water high in total dissolved solids and (or) sulfates decreased weight gains and feed efficiency of steers on a growing ration. Sulfur in the water was associated with a higher rate of polioencephalomalacia. Since water in South Dakota is often high in sulfates and other salts, substantial impacts on economic returns could occur. More research is warranted to examine the effects of poor quality water on performance of grazing cattle and to develop economic models to evaluate management alternatives.

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Table. 1. Total dissolved solids (TDS) and sulfate concentration of water from various sources in western South Dakota in 2001 (ppm)

	Rural Water		Well Water		Dam Water	
Date	TDS	Sulfate	TDS	Sulfate	TDS	Sulfate
June 20	1048	421	4840	3165	5044	3167
July 17	1008	374	4804	3096	5804	3776
July 30	980	410	4812	3174	5874	3667
August 13	1036	404	4864	3120	6380	4107
August 28	1004	421	4764	3044	6744	4359
September 10	1036	394	4928	2920	7300	4603
Mean	1019	404	4835	3087	6191	3947

Table 2. Intake and performance of growing steers supplied water from various sources in western South Dakota in 2001 (Least squares means ± SEM)

Item	Rural Water	Well Water	Dam Water
Observations	3	3	6
Initial wt, lb	701 ± 4	695 ± 4	699 ± 2
Final wt, lb	816 ± 9[a]	782 ± 9[b]	785 ± 7[b]
ADG, lb/d	1.38 ± 0.07[a]	1.02 ± 0.07[b]	1.02 ± 0.04[b]
Water intake, gallons/d	12.6 ± 0.5[c]	10.9 ± 0.5[d]	11.1 ± 0.3[d]
Dry matter intake, lb/d	17.7 ± 0.4[c]	16.5 ± 0.4[d]	16.8 ± 0.2[d]
Gain/Feed	0.078 ± 0.004[a]	0.061 ± 0.004[b]	0.061 ± 0.003[b]

[a,b]Within a row, means without a common superscript letter differ *($P < 0.05$).*

[c,d]Within a row, means without a common superscript letter differ *($P < 0.10$)*.

Table 3. Health of steers supplied water from various sources in western South Dakota in 2001[a]

Item	Rural Water	Well Water	Dam Water
Morbidity, %[b]	0.0	25.0	15.0
Mortality, %	0.0	5.0	5.0
Polioencephalomalacia, %[c]	0.0	15.0	12.5

[a]Data analyzed by Chi-Square analysis (observations = 12; events = 81).

[b]*$P < 0.05$.*

[c]*$P < 0.10$.*