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2004

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Recommended Citation
Johnson, Patricia S.; Patterson, Hubert H.; and Haigh, Ronald, "Effects of Sulfates in Water on Performance of Steers Grazing Rangeland" (2004). *South Dakota Beef Report, 2004.* Paper 9.
http://openprairie.sdstate.edu/sd_beefreport_2004/9

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Effects of Sulfates in Water on Performance of Steers Grazing Rangeland

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BEEF 2004 – 08

Summary

Surface and subsurface water in South Dakota often contains high concentrations of total dissolved solids (TDS) and sulfates, which, in severe cases, can cause livestock deaths. Data from our laboratory have demonstrated that sulfate concentrations of 3,000 ppm in water consumed by steers in dry-lot decreased ADG, feed intake, and water consumption. Little information is available on the effects of water sulfate concentrations on grazing livestock. This study evaluated the effects of water quality and two vegetation communities on the performance of steers grazing rangeland. Eight native pastures at the SDSU Cottonwood Research Station were used. Four pastures were dominated by warm-season shortgrasses (**SG**) and four by cool-season midgrasses (**MG**). Yearling steers (105/year) were allotted to pastures in 2001 and in 2002 to attain a moderate stocking rate of 0.50 AUM/acre during a 4-month grazing season. In 2002, cattle were removed after two months due to drought, resulting in a stocking rate of 0.25 AUM/acre. Number of cattle per pasture varied from 7 to 30, depending on pasture size. Cattle in two of the SG and two of the MG pastures received high sulfate water (**HS**, 2001: average = 3,947 ppm sulfates; 2002: average = 4,654 ppm sulfates) with low sulfate water (**LS**, 2001: average = 404 ppm sulfates; 2002: average = 441 ppm sulfates) provided in the remaining pastures. Average daily gain was greater for the LS steers than HS steers in 2001 (*P* = 0.003; 1.85 and 1.65 lb/d, respectively) and in 2002 (*P* = 0.001; 2.43 and 1.79 lb/d, respectively). An interaction between sulfate concentration in water and vegetation community in 2002 (*P* = 0.078) resulted from similar ADG for steers on SG (1.83 lb/d) and MG (1.74 lb/d) pastures for HS water, but greater ADG for steers on MG (2.54 lb/d) than SG (2.32 lb/d) pastures for LS water. During the two-year study, only one steer had health problems related to sulfur, with no deaths. Our study showed water with sulfate concentrations of 3,947 ppm and greater reduced ADG of grazing steers, and that the response was influenced by vegetation.

Introduction

Water is a critical resource on semi-arid rangelands of the western United States, including western South Dakota. Livestock production on these rangelands is absolutely dependent on adequate quantity and quality of water. Field observations from our research since 1999 have shown both surface and subsurface water in South Dakota often exhibit high levels of total dissolved solids (**TDS**) and sulfates. We have shown that the majority of the salts (approximately 70%) in high TDS water sources in the region are sulfate salts. Gould et al. (2002) concluded that 6% of 498 subsurface water samples taken in regions across the United States had sulfates greater than 1000 ppm, with 50% of those coming from water in the North-Central Region (SD, ND, NE, and KS). The authors reported that in multiple locations in South Dakota, sulfur intake from water and forage exceeded the NRC (1996) maximum tolerable level of dietary sulfur (0.4% of DM). Drought conditions in 2002 further exacerbated water quality problems in South Dakota due to minimal stockdam water recharge and concentration of salts as water evaporates.

Data from our research showed that growing steers in dry-lot receiving water with over 3,000 ppm sulfates had reduced average daily gain, DM intake, water intake, and gain/feed (Patterson et al., 2003). Steers receiving the high sulfate water had a high rate of polioencephalomalacia (**PEM**), a metabolic disorder induced by high sulfur ingestion. We

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also reported that water intake decreased linearly and average daily gain, dry matter intake and gain/feed decreased quadratically as TDS and sulfate levels increased for steers in dry-lot (Patterson et al., 2003). Much of the research on the effects of high sulfate water has been done in drylot. Little information is available on the effects of high sulfate water on the performance of cattle grazing rangeland. It is reasonable to expect that environmental and forage moisture differences between dry-lot and rangeland situations will affect water intake and consumption of sulfate salts, and, therefore, animal responses to high sulfate water. Such information is needed because of the prevalence of grazing livestock in the region that are affected by high TDS/sulfate water and the potential economic impact of any reductions in animal performance. The type of forage available to grazing livestock affects animal weight gains (e.g. Lewis et al., 1956), thus it is important to examine any potential interaction between type of forage and water quality on animal performance.

The objective of this study was to determine the effects of water quality on the performance of steers grazing two different rangeland plant communities.

Materials and Methods

The study was conducted at South Dakota State University's Cottonwood Range and Livestock Research Station, near Philip, SD in 2001 and 2002 on eight native pastures. Four pastures were dominated by warm-season shortgrasses (SG), including blue grama (*Bouteloua gracilis* (H.B.K.) Lag. Ex Griffiths) and buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.). The remaining four pastures were dominated by cool-season midgrasses (MG), including western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Love) and green needlegrass (*Stipa viridula* Trin.). One hundred and five crossbred yearling steers (635 and 648 lb in 2001 and 2002, respectively) were stratified by weight and randomly assigned to one of eight pastures in each year to attain a moderate stocking rate of 0.50 AUM/acre during a 4-month grazing season. In 2002, cattle were removed after two months due to drought, resulting in a stocking rate of 0.25 AUM/acre in that year. Cattle grazed study pastures from 18 May to 6 September in 2001 and 22 May to 23 July in 2002. Number of cattle per pasture varied from 7 to 30, depending on pasture size. Cattle in two of the SG and two of the MG pastures received high sulfate water (HS, 2001: average = 3,947 ppm sulfates; 2002: average = 4,654 ppm sulfates) with low sulfate water (LS, 2001: average = 404 ppm sulfates; 2002: average = 441 ppm sulfates) provided in the remaining pastures. All water was obtained from natural sources, and sulfate levels were created by mixing water to form the desired salt level. Water samples were collected each time new water was supplied, and a weekly composite sample was analyzed for sulfate concentration. The average analyses of water samples collected throughout the trial for each water treatment are shown in Table 1. Since we were working with natural water sources, exact target levels were not achieved. Low sulfate water was derived from our rural water system and sulfates varied little within or between years (375 – 420 ppm in 2001 and 375 – 490 ppm in 2002). High sulfate water in 2001 was derived entirely from a stock dam in which sulfate concentrations increased from 3,170 – 4,600 ppm over the grazing season. High sulfate water in 2002 was a blend of water from two natural sources, with the blends ranging from 4,550 – 5,390 ppm sulfate.

Water was supplied to each pasture in tanks. Water consumption was measured by the daily change in water depth adjusted for evaporation and precipitation. Measurements of evaporation and precipitation were taken from a weather station located at the research station headquarters, no more than two miles from all pastures. Animal health was monitored daily.

Steer weights were measured at the beginning and end of the experiment in each year. Access to feed and water was denied during a 12-h overnight period prior to weight measurements. Steer ADG was averaged within each experimental unit (pasture).

Analysis of variance (SYSTAT Linear Models II, SYSTAT, Richmond, CA) was used to evaluate the influence of sulfate level, pasture type, and their interaction on steer ADG and water intake.

Results and Discussion

Steers consuming high sulfate water had significantly lower ADG in both years (P = 0.003 and 0.001 for 2001 and 2002, respectively) compared to LS water (Table 2). In 2001, the

HS treatment resulted in a 10.7% reduction in ADG compared to LS, and in 2002 the reduction was 26.4%. Water intake was not different (*P* = 0.456) between water treatments in 2001, but in 2002 steers consumed more water in the LS treatments (*P* = 0.061). These results are similar to, though not as dramatic as, those from companion studies in the same years at the Cottonwood Research Station in which yearling steers in dry-lot experienced lower ADG and water intake on high sulfate compared to low sulfate water (Patterson et al., 2003, 2004).

The greater effect of high sulfate water on ADG and water intake in 2002 compared to 2001 may be explained by environmental conditions. Spring precipitation in 2001 resulted in some pooling of water in low-lying areas of pastures, providing steers with intermittent alternate water sources during the first six weeks of the study. Extremely dry conditions in spring of 2002 precluded availability of alternate water sources in that year and forced HS animals to consume the HS water exclusively. The alternate water sources in 2001 likely reduced intake of water provided in pasture tanks and may explain the low water intake values measured in 2001 (Table 2). In that year, water intake by HS and LS steers was not different (*P* = 0.456). In 2002, when alternate water sources in pastures were unavailable, water intake was greater for LS steers compared to HS steers (*P* = 0.061). In 2002, steers were removed from pastures 48 d earlier than in 2001 due to drought. Although forage was in short supply in 2002, forage quality may have been elevated, especially for cool-season forages (Wilson, 1982).

There was an interaction between pasture and water treatment for ADG (Figures 1 and 2) in both years of the study (*P* = 0.027 and 0.078 in 2001 and 2002, respectively). In both years, ADG was greater for steers grazing MG pastures compared to SG pastures when drinking water contained low sulfate concentrations. This is in keeping with the work by Lewis et al. (1956), who reported that MG pastures at the Cottonwood Research Station typically produced greater livestock gains compared to SG pastures. If, however, drinking water supplied to livestock contains high concentrations of sulfates, the data from this study indicate that there is no advantage in ADG for MG pastures.

Throughout the two years of this study, only one steer (in the HS treatment in 2001) was identified as exhibiting symptoms of PEM. The steer was treated and recovered. That is in stark contrast to the incidence of PEM that occurred in dry-lot for steers drinking water with similar sulfate concentrations. In 2001, there was a 15% and 12.5% incidence of PEM for steers in dry-lot drinking water with sulfate concentrations of 3,087 and 3,947 ppm, respectively (Patterson et al., 2003). In 2002, steers in dry-lot consuming water with a sulfate concentration of 4,654 ppm had a 47.6% incidence of PEM (Patterson et al., 2004). We hypothesize that the differences in responses (ADG, water intake, PEM) to sulfate concentrations in drinking water between dry-lot and pasture steers are likely due to a number of factors. Moisture content of early-season forage on pasture is higher than in dry rations fed to dry-lot cattle, thus reducing the water requirement of grazing animals. Environmental conditions, including high surface temperatures, lack of shade, and reduced wind flow, likely result in greater heat stress in dry-lot situations and greater water requirements.

We conclude that water with 3,947 ppm sulfates and higher reduced water consumption and animal performance for steers grazing native rangeland. We also determined that there was an interaction for ADG between pasture type and water sulfate concentration. Steers grazing midgrass-dominated pastures had greater weight gains than steers grazing shortgrass-dominated pastures when water sulfate concentrations were low. At high water sulfate concentrations, steers grazing midgrass- and shortgrass-dominated pastures had similar gains.

Implications

These data, combined with field observations, suggest that water quality may be inadequate for optimal range livestock production in a significant portion of South Dakota. Reduction in animal weight gains can be expected for cattle on pasture drinking water with a sulfate concentration of 3,947 ppm or greater. Midgrass-dominated pastures may be an advantage for steer weight gains when water sulfate levels are low, but that advantage is eliminated when water sulfate levels exceed 3,900 ppm.

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Tables

Table. 1. Average TDS and sulfate analyses (ppm) of water with either low (LS) or high (HS) sulfate levels provided to growing steers on pasture in western South Dakota in 2001 and 2002

	2001		2002	
Item	LS	HS	LS	HS
TDS	1,019	6,191	1,226	7,268
Sulfate	404	3,947	441	4,654

Table 2. Performance and water intake of growing steers on pasture supplied water with either low (LS) or high (HS) sulfate levels in western South Dakota in 2001 and 2002

	2001		2002	
Item	LS	HS	LS	HS
Initial Weight, lb	630	636	630	622
Final Weight, lb	836	822	795	754
ADG, lb/d[a]	1.85	1.65	2.43	1.79
Water Intake, gallons/d[b]	7.5	7.3	11.6	10.1

[a]Means within year significant (P = 0.003 for 2001; P = 0.001 for 2002).
[b]Means within year not significant (P = 0.456) in 2001 and significant (P = 0.061) in 2002.

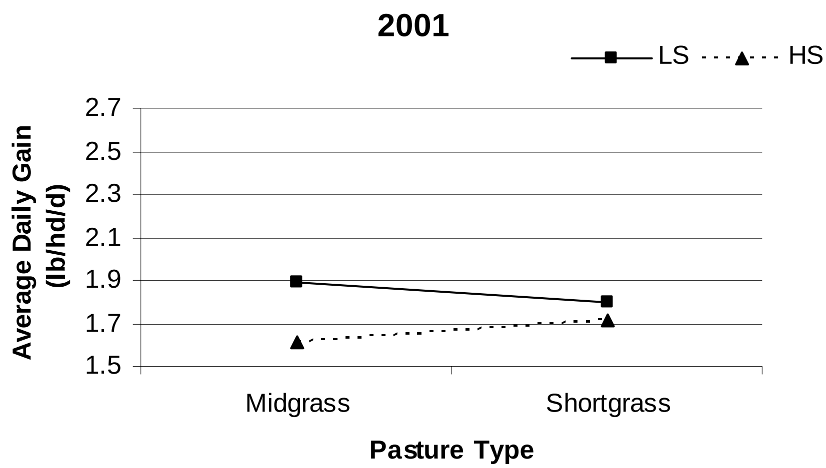

Figure 1. Interaction between sulfate concentration (LS = 404 mg/L; HS = 3,947 ppm) and pasture type (midgrass-dominated and shortgrass-dominated) for average daily gain (lb/hd/d) for steers grazing native pastures in 2001 (*P* = 0.027).

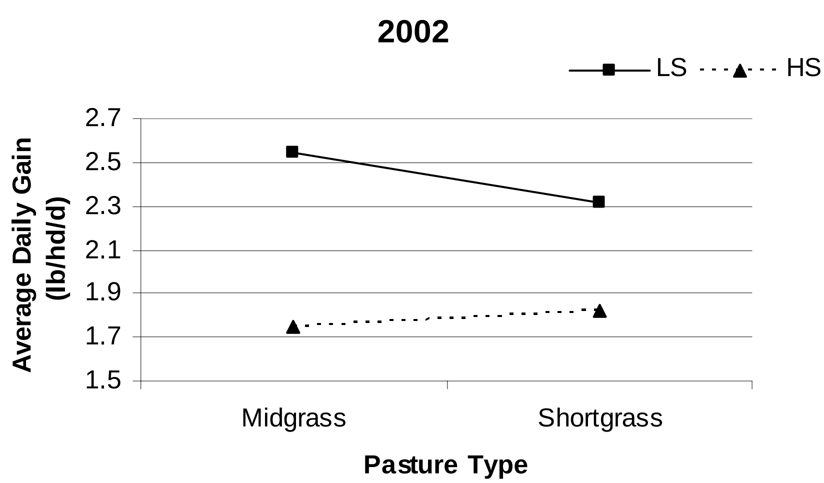

Figure 2. Interaction between sulfate concentration (LS = 441 ppm; HS = 4,654 ppm) and pasture type (midgrass-dominated and shortgrass-dominated) for average daily gain (lb/hd/d) for steers grazing native pastures in 2002 (*P* = 0.078).