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CONDITIONING CATTLE TO WATER STRESS

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In previous water stress research at this station, the effects of repeated intervals off water, up to 48 hr were examined. Except for reduced performance of the suckling calf and bred replacement heifers, no detrimental effects were observed (Sneva et al., 1973; Sneva et al., 1975). The ability of range livestock to be conditioned to tolerate water stress has not been considered in published grazing studies nor has the length of time off water when livestock on rangeland become susceptible to water intoxication been determined.

In this study, the effects of repeated periods of water stress conditioning on a final period of 96 hr off water were examined. The paper presents animal performance, water consumption, blood and urine analyses, and lignin-ratio derived digestibility coefficients.

Methods and Materials

Sixteen yearling Hereford heifers, averaging 240 kg, were stratified by weight and randomly alloted (4/treatment) to 3-ha crested wheatgrass pastures. Salt and a 50-50 salt-bonemeal mix was provided ad libitum in each pasture. Animals began with ad libitum water; water stress intensity became progressively more intense with time for some treatments (table 1). Initial study weights were obtained June 4 after a preconditioning period of about 30 days on crested wheatgrass with ad libitum water. The influence of the conditioning treatments was evaluated in a final two-cycle, 96 hr off water period followed by a 6-day ad libitum water period. Heifers were held off water and feed overnight before they were weighed. Sampling times for blood, urine, feces, and forage were scheduled around weigh dates. Weigh dates were scheduled so that upon return to pasture, all treatments were on scheduled access to water. Water intake by individual animals was monitored July 2 to July 20 when ad libitum, 24-, 48- and 72-hr periods off water were in effect. Water intake was also measured August 5 after the first 96 hr off water period.

After the first 96-hr off water period, the animals were moved to corrals and held through the recovery period. Alfalfa hay was fed to the heifers during this part of the study.

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Digestion coefficients were determined from fecal grab samples on July 25 and from a 3-day (July 28 to 30) composite taken from the first defecation of each day. The available pasture herbage was sampled concomittantly. Forage and fecal analyses followed those prescribed by A.O.A.C. (1965); however lignin analyses followed those prescribed by Van Soest and Wine (1968) as modified by Rittenhouse (1969).

Blood and urine were sampled in the evening after gathering. In addition, animals on ad libitum and 72-hr off water treatments were sampled at 2, 4, and 21 hr after their reentry to water on August 9 after the final 96-hr off water period. Samples were refrigerated and then subsequently centrifuged, and packed cell volume (PCV) was measured. The blood plasma was retained, and blood plasma osmotic pressure (BPOP) was determined over vapor pressure with an osometer and blood plasma protein (BPP) was determined by refraction (Weeth and Speth, 1968).

Collected by external stimulation, the urine samples were also refrigerated and analyzed for urine osmotic pressure (UOP) in the same manner as BPOP, and total dissolved salts (TDS) were determined by refraction (Weeth et al., 1969).

Sequential treatment change normally followed a weigh date. However, in the final conditioning stage, the yearlings were weighed on July 26 and returned to their pasture where their respective treatment was continued. On August 1, they all began the first 96-hr off water treatment without weighing, to eliminate the stress associated with trailing and subsequent handling.

Results and Discussion

The heifers adjusted rapidly to their changing water frequencies. When the tank lids were opened at 11 a.m. the heifers came quickly to water. They rarely spent more than 10 minutes drinking then they began to graze while moving away from water. If their tank lid was not opened, they would remain at a distance. Although animals had access to water for a 2-hr period, they did not return for a second drink. Heifers on the 48 and 72-hr periods off water were more alert, nervous, and active than heifers on less intense water stress. At the end of the first 96-hr period off water, heifers on ad libitum and 24 hr off water were listless and could be approached without their dispersion. In contrast, heifers conditioned to more intense water stress were alert and nervous and could not be approached without their dispersion. When water was offered at the close of the first 96-hr period off water, heifers conditioned ad libitum and 24-hr off water moved to water very slowly; those conditioned to more intense water stress came quickly. We observed these animals for 4 hours after their drinking of offered water after the first 96-hr period off water. The first animal urinated one-half hr after drinking. No symptoms of water intoxication were evident during this 4-hr period. The next morning, one heifer was down and unable to regain her feet. Intravenous feeding of an electrolytic solution was begun immediately. While this animal was being treated, another heifer went down twice but was able to get up unassisted. Both heifers were from the group previously conditioned to 24-hr off water. The two stricken animals remained in the study pasture and were bucket watered for several days and then removed from the study. During the second 96-hr off water period, there were no visual differences as had been observed in the field; furthermore, no additional signs of water intoxication were observed after access to water.

Average daily gain (ADG) of heifers (table 2) reflects treatment response, forage quality, and environmental factors, principally temperature. During the study period, the forage crude protein decreased 10.4, 8.1, 6.2, and 4.2% on sample dates June 3, June 19, July 1, and August 1, respectively, whereas forage dry matter increased 39, 45, 59 and 76% respectively. Mean day temperature averaged 18C from June 4 through July 25. The temperature increased to 22C during the severest stress period (July 26 through August 8) but decreased to 16C during the recovery period (August 9 through 16).

The ADG of heifers in this study, as in previous studies, was reduced ($P < .05$) when the period off water was longer than 24-hr. Negative ADG was recorded when water was offered every 72-hr. All heifers lost weight during the two, 96-hr off water periods, but loss was greatest from animals conditioned to the more severe water water stress treatments. However, compensatory gains during the recovery period were much greater for those heifers previously conditioned to the most severe water stress treatemnts. The ADG of heifers for the 92 days of the study was 0.6, 0.7, 0.6, and 0.4 kg for ad libitum, 24-, 48-, and 72-hr off water periods, respectively. The gain of only the most severely stressed group was reduced ($P < .05$) from that of other treatments.

The average water drunk from July 2 through July 20 was 30.7, 31.4, 20.8, and 17.0 liters/head/day for the ad libitum, 24-, 48-, and 72-hr off water treatments, respectively. The reduced ($P < .05$) intake by the 48-, and 72-hr off water groups was less than that of the ad libitum and 24-hr off water treatments. These amounts are approximately 102, 68, and 56% consumption of the ad libitum treatment for 24-, 48-, and 72-hr off water treatments, respectively. During the measurement period, mean day temperature was 17C; the mean wind speed was 6.4 km/hr; the mean day insolation was 514 langleys; the total precipitation was 1.6 cm. The average water drunk at the end of the first 96-hr off water period was 51.5 liters per animal, approximately 170% of normal daily ad libitum intake. When prorated for the days off water, the estimated daily intake was 12.1, 11.4, 14.8, and 13.2 liters per head for ad libitum, 24-, 48-, and 72-hr off water treatment, respectively. On the prorated basis, daily water consumption during the 96-hr off water period was less than 50% of normal ad libitum daily water intake. The two groups conditioned to the most severe water stress drank the greatest amounts of water.

Fecal dry matter of heifers on ad libitum water treatments averaged 12%. Water stress treatments of 48 and 72-hr off water increased ($P < .05$) fecal dry matter from 4 to 6 percentage units. At the end of the second 96-hr off water period, fecal dry matter for water stress treatments of 24, 40, and 72-hr off water were increased ($P < .05$) 14 to 15 percentage units above that of the ad libitum group, which remained at 12%

The July 25 analyses of fecal grab samples estimated dry matter digestion at 50.6, 60.8, 63.0, and 58.3%, respectively for the same treatment order. Mean treatment differences approached significance at the $P = .05$ level. The low estimate for the ad libitum treatment for the grab sample was strongly influenced by one extremely low analysis. The trend for increased digestion as water stress increased up to 48-hr off water was similar to that observed in a previous trial by Sneva et al. (1973) and that reported by Thorton and Yates (1968) and Asplund and Pfander (1972). These results suggest that, from the composite field but not from the grab samples, dry matter digestion decreased for the 72-hr off water treatment.

Because that water stress treatment also resulted in negative animal weight gain, it is inferred that the decreased dry matter digestion at 72-hr off water may be real and due to an upset in the digestive process.

Blood composition values from August 8 through August 9 + 21 hr may be in error. Upon the removal of blood from refrigeration, some ice crystals were evident. Some hemolysis was observed during centrifuging. However, there is no indication of a blanket effect in the data; therefore, the data were considered valid.

Off water treatments of 48-hr or less had little or no influence on blood composition. Therefore, only values for the ad libitum and 72-hr off water treatments from July 25 are presented and discussed. The packed cell volume (PCV) was increased ($P < .05$) in heifers stressed at 72-hr off water (table 3). The difference between the ad libitum water and the 72-hr off water treatment increased during the two, 96-hr off water periods, but statistical difference at $P = .05$ was not achieved. During the recovery period, the PCV increased similarly for both treatments during the first 21 hours. By August 15, PCV values of both treatments had decreased but were still above the ad libitum treatment before any water stress.

The BPP of heifers stressed at 72-hr off water tended to be higher than that of the ad libitum water treatment (table 3). Only on July 25 was the difference between treatment means different ($P < .05$).

BPOP was higher ($P < .05$) in heifers conditioned to 72-hr off water and while they were subjected to 96-hr off water than in heifers conditioned to ad libitum water and subjected to 96-hr dehydration (table 3). During the first 21-hr of the recovery period a significant ($P < .05$) interaction occurred because BPOP in heifers conditioned to ad libitum water tended to decrease but that of heifers conditioned to 72-hr off water decreased sharply in the first 4 hours and then increased. The UOP and TDS of heifer urine were similarly and more rapidly influenced by water stress than were the blood components (table 4).

Increases ($P < .05$) in UOP and TDS were detected in heifers conditioned to 48 and 72 hr off water. On August 8, after the two, 96-hr off water periods, the UOP and TDS in heifers conditioned to 24, 48 and 72 hr off water were all higher ($P < .05$) than those of heifers conditioned to ad libitum water. The ad libitum group was not affected by the 96-hr off water stress period. At the end of the recovery period, urine composition had returned to near-normal levels.

The 96-hr off water treatment caused water intoxication in 2 heifers that previously had been conditoned to the 24 hr off water treatment. In this study, water consumption and ADG of the 24-hr off water treatment for the study period was greater, but not significantly so, than that of the ad libitum water group. In previous trials (Sneva et al., 1973), similar response in some instances were also recorded. These data suggest that the 24-hr off water treatment did not constitute a "water stress," but that the regularity of watering establishes a pattern in animal activity that may be beneficial; however, an upset in the schedule could be deterimental to animal performance.

On the basis of actual incidence of water intoxication, the fact was not clearly established that conditioning provided greater protection against

water intoxication. However, on the basis of the visual behavior of these heifers in the field on the last day of the 96-hr off water treatment, heifers conditioned to 48 and 72 hr off water were more alert and active than those on lower stress treatments. Heifers conditioned to 48 and 72 hr off water also drank the most water without becoming intoxicated after the 96-hr off water period.

Summary

A 96-hr dehydration period was used to test the susceptibility of preconditioned yearling Hereford heifers to water intoxication. Conditioning treatments were ad libitum water and water every 24,48, and 72 hr while on crested wheatgrass. Blood and urine composition, water drunk, fecal dry matter, dry matter digestion, and average daily gains were measured during selected periods.

Two heifers conditioned to 24 hr off water became intoxicated after the 96-hr off water period. These heifers became intoxicated after more than 4 hr after drinking. Yearlings conditioned at 48 and 72 hr off water were visually more alert and active in the last day of the 96-hr dehydration period than heifers conditioned to ad libitum and 24 hr off water.

Heifers stressed at 48 and 72 hr off water drank 32 and 44% less water than heifers on ad libitum water. After the 96-hr dehydration period, the water drunk averaged 170% of the normal daily intake, and those conditioned to the more severe water stress drank the greatest amount of water.

Fecal dry matter increased about 4 percentage units with water stress treatments of 48 and 72 hr off water during the conditioning period. The 96-hr dehydration period did not alter fecal dry matter concentration of heifers conditoned to ad libitum water but did increase that of heifers conditioned to greater water stresses.

Dry-matter digestion increased as water stress increased up to 48 hr, but differences ($P < .05$) among treatment means were not reached.

In the conditioning period, only the 72-hr off water treatment caused significant change in the PCV, BPP, and BPOP. After the 96-hr dehydration period, the BPOP was significantly higher in heifers conditioned to 24, 48, and 72 hr off water than in heifers conditioned to ad libitum water.

UOP and TDS in the urine were increased during the conditioning period by water stress period of 48 hr or longer and by the 96-hr dehydration. Urine components of heifers conditioned to 24 hr off water were increased above that of ad libitum conditioning treatment only during the 96-hr dehydration period.

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Table 1. Sequence of water stress treatments

Grazing period[a]				
6/4-6/18	6/18-7/2	7/2-8/1	8/1-8/9	8/9-8/16
Ad libitum (4)	Ad libitum (4)	Ad libitum (4)	1/96 hr (4)	Ad libitum (4)
1/24 hr (12)	1/24 hr (4)	1/24 hr (4)	1/96 hr (4)[b]	Ad libitum (2)
	1/48 hr (8)	1/48 hr (4)	1/96 hr (4)	Ad libitum (4)
		1/72 hr (4)	1/96 hr (4)	Ad libitum (4)

a/ Number in ( ) refers to number of animals for that treatment period.

b/ Two heifers removed after the first 96 hr off water period.

Table 2. Yearling average daily gain (kg/hd/dy)

Treatment[a] (hours off water)	Grazing period				
	6/4-6/18	6/18-7/2	7/2-7/25	7/25-8/9	8/9-8/16
Ad libitum	1.0[c]	0.6[c]	0.8[c]	-0.8[c]	1.8[c]
24[b]	1.5[d]	0.8[c]	0.9[c]	-3.0	6.4
48		0.3[d]	0.2[d]	-1.8[d]	6.3[d]
72			-0.1[d]	-1.3[c,d]	5.1[d]

a/ During the conditioning period (June 4-August 1).

b/ Two heifers removed from treatment because of intoxication during last two grazing periods.

c,d/ Means within a date with different letters differ significantly ($P < .05$).

Table 3. Blood composition during the recovery and final water stress period of heifers previously conditioned to ad libitum (0) and 72 hr off water.

Sample date	PCV[a]		BPP[b]		BPOP[c]	
	0-hr off-water	72-hr off-water	0-hr off-water	72-hr off-water	0-hr off-water	72-hr off-water
7/25	43.0[g]	47.2[h]	7.22[g]	7.94[h]	284[g]	298[h]
8/8	45.2[g]	53.2[g]	7.57[g]	7.93[g]	283[g]	304[h]
8/9+2 hr[e]	52.2[g]	54.5[g]	7.62[g]	7.94[g]	277[g]	274[g]
8/9+4 hr[e]	55.0[g]	55.8[g]	7.61[g]	7.78[g]	271[g]	249[g]
8/9+21 hr[e]	60.2[g]	58.2[g]	7.62[g]	7.52[g]	268[g]	264[g]
8/15[f]	49.0[g]	50.0[g]	7.22[g]	6.95[g]	274[g]	270[g]

a/ Packed cell volume (mm).

b/ Blood plasma protein (g/100 ml).

c/ Blood plasma osmotic pressure (MOsm/kg H_2O).

d/ Sampled after second 96-hr off water period.

e/ Sampled after drinking after 96-hr off water period.

f/ Sampled at close of 6-day ad libitum recovery period.

g,h/ Statistical difference ($P < .05$) between treatment means denoted by unlike letters within a row.

Table 4. Urine composition after ad libitum water recovery and a final 96 hr off water treatment after various conditioning treatments

Sample date	Ad libitum	24 hr off water	48 hr off water	72 hr off water	Ad libitum	24 hr off water	48 hr off water	72 hr off water
7/1	550[e/]	376[e/]	981[f/]	932[f/]	4.27[f/]	2.18[e/]	7.30[f/]	6.45[f/]
7/25	428[f/]	222[e/]	924[g/]	943[g/]	3.28[e/]	1.80[e/]	6.84[f/]	8.30[f/]
8/8	395[e/]	1095[f/]	1090[f/]	1040[f/]	2.42[e/]	6.01[f/]	6.60[f/]	5.82[f/]
8/15	579[e/]	648 [e/]	832[e/]	607[e/]	3.47[e/]	3.74[e/]	4.50[e/]	3.56[e/]

a/ Urine osmotic pressure in MOsm/kg H_2O).

b/ Total dissolved salts in g/100 g.

c/ Sampled after the second, 96-hr off water period.

d/ Sampled after the end of ad libitum recovery period.

e,f,g/ Statistical significance ($P < .05$) between treatments within dates denoted by unlike letters.