Mineral salt supplementation of cattle grazing tall larkspur-infested rangeland during drought

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Abstract

Mineral salt supplements are used in attempts to reduce cattle losses to tall larkspur (*Delphinium* spp.). We determined the effects of a mineral salt mix on larkspur consumption, ruminal fluid kinetics, and water intake during 4 periods in June, July, and August, 1988 (Trial 1), and during an 18-day grazing period in August, 1989 (Trial 2). In 1988, 12 ruminally cannulated heifers were divided into 3 treatment groups: control with no access to mineral (CONT), 0.5 g mineral • kg body weight^{-1} •day^{-1} (HIGH) dosed intraruminally. In 1989, 10 cows were allocated to either a control group or 0.75 g mineral • kg body weight^{-1} • day^{-1}. During Trials 1 and 2, consumption of larkspur peaked at 5 and 7% of cattle diets, respectively; these low levels were attributed to drought. There were no differences (P>0.1) in consumption of total larkspur or larkspur plant parts. Mineral supplement increased water consumption (P<0.05) during Trial 1, but not during Trial 2. The HIGH group averaged 0.1 liters • kg body weight^{-1} • day^{-1} compared to 0.07 liters for the CONT and LOW groups. Ruminal fluid passage rate, turnover time, volume and fluid outflow rate (FOR) did not differ (P>0.05) among treatments during Trial 1, but FOR was increased by mineral treatment in Trial 2. Alkaloid concentration in larkspur declined with maturity, and was apparently elevated by drought in Trial 2. This study found little indication that mineral salt supplement altered the amount of larkspur consumed by grazing cattle. Increased water intake one summer did not alter ruminal fluid kinetics. If dietary minerals alter toxicity of larkspur to cattle, other mechanisms than those tested are responsible.

Key Words: poisonous plants, *Delphinium* spp., cattle diets, alkaloids, toxicity

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Tall larkspur (*Delphinium* spp.) is a major cause of cattle losses on mountain ranges in the U.S. (Ralphs et al. 1988). Preventative measures to reduce cattle losses have been sought for many years. One commonly touted measure is mineral salt supplementation (Hughes 1941, Logan 1973, Knowles 1974). Claims that mineral salt supplement reduced cattle deaths (e.g., Hughes 1941) have not been verified under controlled research situations. Studies by Logan (1973) and Knowles (1974) attempted to determine if mineral salt supplements were effective, using death losses and(or) plant-based measurements of larkspur utilization in different pastures. Both studies were inconclusive, in part due to confounding of treatments and pastures.

The objective of this study was to determine if various levels of a mineral salt supplement would influence tall larkspur consumption by cattle. Presumably, mineral-satiated cattle may be less inclined to experience 'specific hungers' (Denton and Sabine 1963) that may exacerbate larkspur ingestion. Further, we wished to determine if mineral supplementation would alter water intake and ruminal fluid passage rate (FPR). Increased mineral salt intake by cattle has increased water intake and FPR (Rogers and Davis 1982, Schneider et al. 1988). Such changes may alter absorption and excretion kinetics of larkspur alkaloids, thus reducing the susceptibility of supplemented animals.

Materials and Methods

Trial 1

Twelve yearling Hereford heifers (mean liveweight 267 kg) were used in 1988. All animals had grazed the previous summer on larkspur-infested ranges near the study pasture. The heifers were randomly assigned to 3 treatment groups (4 animals/treatment): control with no access to mineral (CONT), 0.5 g mineral • kg body weight^{-1} • day^{-1} (LOW), and 1.0 g mineral • kg body weight^{-1} • day^{-1} (HIGH). These doses were chosen because larkspur toxicity tests (J.D. Olsen, personal communication) indicated some

Table 1. Mineral composition (mg/kg unless otherwise noted) and ingredients[a] of "Binns #1 Alleviator" mineral salt mixture[b].

Element	Amount
Al	3,439
B	10.7
%Ca	4.36
Cd	10.0
Co	90.9
Cr	76
Cu	569.0
Fe	2,304
%K	0.81
%Mg	4.33
Mn	76.5
Mo	3.9
Na	197,900
Ni	3
%P	3.83
%S	1.59
Sr	58.1
Zn	1,494.0

[a]Ingredients in this mineral salt mixture as reported on the label: monocalcium phosphate, sodium chloride, monoammonium phosphate, dicalcium phosphate, cane molasses, beet molasses, corn oil, potassium sulfate, magnesium oxide, beet pulp, wheat bran, sodium bicarbonate, calcium carbonate, barley, yeast culture, Vitamin A, D-activated animal sterol, ferrous carbonate, manganous oxide, zinc oxide, copper sulfate, ethylene diamine dihydriodide, cobalt carbonate.
[b]Manufactured and distributed by Walton Feed West, Inc., Cache Junction, Utah 84304.

benefit from this level of supplemental mineral salt. The trace mineral mix was a granulated commercial preparation "Binns No. 1 Alleviator[1]." Micro- and macro-mineral nutrients in the mixture (Table 1) were determined using inductively coupled argon plasma spectrometry[2]. The label states that the mix is formulated "to help reduce losses in areas of larkspur infestation". The mineral was intraruminally dosed each day at about 1200 hours to heifers on the various treatments. Preliminary trials indicated no adverse effects (i.e., inappetence or diarrhea) in ruminally cannulated animals dosed for several weeks with the HIGH level.

Cattle grazed on pastures infested with duncecap larkspur (*Delphinium occidentale* [Wats.] Wats.) in the Sawtooth National Forest in southern Idaho near Oakley at 2,500 m elevation. Besides *D. occidentale,* other dominant plants included mountain big sagebrush (*Artemisia tridentata vaseyana* [Rydb.] J. Boivin), snowberry (*Symphoricarpos oreophilus* Gray), Great Basin wildrye (*Elymus cinereus* Scribn. & Merr.), Idaho fescue (*Festuca idahoensis* Elmer), oniongrass (*Melica bulbosa* Geyer), yarrow (*Achillea millefolium* L.), mountain dandelion (*Agoseris glauca* [Pursh] Raf.), and goldenrod (*Solidago canadensis* L.). Phenological stages of *D. occidentale* were used to define 4 grazing periods: bud stage (15 to 24 June), early flower (29 June to 8 July), full flower (12 to 21 July), and pod stage (26 July to 2 August). Most *D. occidentale* plants were in each phenological stage during the respective periods. During the bud stage, plants had not yet elongated reproductive racemes; during early flower most racemes had elongated but flowers had not opened fully. Initially a 2.8-ha pasture was established with an electric fence for the first period; this pasture was expanded to 3.6, 4.4, and 5.3 ha for subsequent grazing periods so that forage availability was not restricted. Heifers were given several days adaptation to pastures and dosing regime when the study began, and were maintained on their treatments in a pen and fed alfalfa hay between grazing periods.

Cattle diets were quantified using daily bite counts (Pfister et al. 1988a,b). Order of observation was predetermined at the start of the study. Beginning at daybreak, each heifer was focally observed for a 5-min period before observing the next heifer. Heifers were continuously observed in sequential order during all active grazing periods until dark. Generally, we obtained about 20 min of daily observation time on each animal. Bites were categorized as shrubs, grasses, other forbs, and larkspur bud, flower, pod, leaf or leaf and stem.

Research on animals' diets using bite counts is limited by the number of animals that can be observed. Only 1 mineral salt mix was tested because of limitations in animal numbers. Two other common measures of diet composition, fecal analysis and use of esophageally fistulated animals, were considered and rejected. Fecal analysis is not an option because larkspur lacks distinguishing epidermal characteristics, and fecal analysis also would obscure the episodic nature of larkspur consumption. Esophageally fistulated animals are also not a viable alternative because of the episodic nature of larkspur consumption by grazing cattle.

Ruminal fluid passage rate (FPR; %/hour) was quantified during the last 24 hours of each period for the CONT, LOW, and HIGH groups by dosing intraruminally at 0700 with 500 ml of cobalt ethylenediaminetetraacetate (Co-EDTA; Uden et al. 1980). The Co-EDTA doses contained 2600, 2530, 2510, and 2361 mg Co/liter for the 4 periods, respectively. Rumen samples were taken at 0, 4, 8, 12, and 24 hours post-dosing, and frozen at -20° C. After centrifugation at 10,000 $\times$ g for 20 min, the supernatant fluid was filtered with a 0.2 μm membrane filter. Co concentrations were determined using atomic absorption spectrophotometry with an air-acetylene flame, and FPR calculated by regression of the natural logarithm of Co concentration on time. Rumen volume (VOL; liters) was calculated by dividing Co dose by ruminal Co concentration extrapolated to time 0. The reciprocal of the slope gave turnover time (TOT; hours). Fluid outflow rate (FOR; liters/hour) was calculated as VOL $\times$ FPR. The mineral salt mixture contained cobalt (Table 1), but rumen fluid taken before addition of the Co-EDTA solution contained only 0-0.5 mg Co/liter.

Water intake was measured over 2 days near the end of each period, but not during the times when FPR was measured. Water was available only in a large corral, and the heifers were habituated to entering the corral to drink each day around 1200. On the day before initial water intake measurements, animals were herded to water at 1230, and allowed to drink ad libitum until 1300, when they were shut off from water. During the subsequent 2 days, all animals were gathered at 1230, and given two 5-min opportunities in the next 2 hours to drink individually while consumption was measured. Total water consumption (liters/heifer) over the 2 days was divided by 2 to obtain daily average water consumption. We verified that animals would drink their fill during the alloted times by allowing the entire group access to water after all animals were tested twice. Only twice did an animal approach the water and drink, and only a few sips were taken.

Blood samples were drawn by jugular venipuncture into tubes with no additives on 22 July and 5 Aug. 1988. After allowing blood to clot, serum was separated by centrifugation and frozen at -20° C. Although blood mineral levels do not mirror dietary mineral intake, blood values have been useful as indicators of normal mineral metabolism (Samokhin 1982). Blood calcium (Ca) levels were determined on duplicate serum samples using an automated blood analyzer[3], using established procedures and reagents.

Standing crop of vegetation was measured at the beginning and end of each grazing period by clipping thirty .25-m^2 plots to ground level. Plots were randomly placed along transects, and clipped material was separated into *D. occidentale,* other forbs, and grasses.

[1]Walton Feed West, Inc., Cache Junction, Utah 84304. Mention of a trade name, proprietary product or specific equipments does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.
[2]Jarrell-Ash ICAP 9000 Plasma Spectrometer
[3]Abbott Biochromatic Analyzer 200

Table 2. Water consumption (liters • kg body weight^{-1} • head^{-1} day^{-1}) and ruminal fluid passage rate (%/hour), volume (liters/kg body weight), turnover time (hours) and outflow rate (liters/hour) for cattle on various mineral salt supplement levels during 1988 and 1989.

	Mineral dose (g • kg body weight^{-1} • day^{-1})				Period				
Item	0.0	0.5	1.0	Response[a]	1	2	3	4	Response[a]
Trial 1									
Water intake	.07	.07	0.1	L*	.06	.07	0.1	0.1	1 vs 3** 1 vs 4** 1&2 vs 3&4**
Fluid passage rate	12.1	11.6	12.7	NS	12.5	12.8	11.3	11.9	1 vs 3 P=0.06 1 vs 4 NS 1&2 vs 3&4*
Turnover time	8.6	8.9	7.9	NS	8.2	7.8	9.2	8.7	1 vs 3 P=0.08 1 vs 4 NS 1&2 vs 3&4*
Volume	0.23	0.22	0.22	NS	0.20	0.21	0.27	0.22	1 vs 3** 1 vs 4 NS 1&2 vs 3&4**
Fluid flow rate	7.1	6.7	7.3	NS	6.4	7.1	8.0	6.7	1 vs 3** 1 vs 4 NS 1&2 vs 3&4*
	0.0	0.75			Begin	End			
Trial 2									
Water intake	.05	.07		NS	.04	.07			**
Fluid dilution intake	10.3	11.4		NS	10.7	11.1			NS
Turnover time	10.3	8.9		NS	9.6	9.6			NS
Volume	0.22	0.25		NS	0.31	0.16			**
Fluid flow rate	7.7	10.3		*	11.8	6.2			**

[a]L = Linear; *$P<0.05$; **$P<0.01$; NS = Nonsignificant at $P>0.05$

D. occidentale plant parts were harvested periodically for total alkaloid analysis. Plant material was oven-dried at 40° C for 48 hours, then ground through a 1-mm screen in a Wiley mill, and total alkaloid determinations done using the procedures of Manners and Ralphs (1989). Briefly, this entails sequential extraction with ethanol, chloroform, and ether, and determining alkaloid weight after concentrating to dryness.

Daily cattle diets were averaged for each individual for each period and analyzed by analysis of variance procedures (SAS 1987) using a split-plot design with repeated measurements (Gill 1978). Treatments were level of mineral, individual animals were nested within treatment, and the study was repeated during the 4 periods. This analysis was also used for water intake, ruminal fluid variables, and blood Ca, except that serum samples were only taken on 2 dates. Diet composition, water intake, Ca levels, FPR, VOL, TOT, and FOR were tested for linear and quadratic responses using orthogonal polynomials. Specified contrasts were used to test for differences in period 1 vs. 4, periods 1 and 2 vs. 3 and 4, and period 1 vs. 3. When period by treatment interactions were found, simple effect means were separated using the LSD procedure (Steel and Torrie 1980).

Trial 2

Ten ruminally cannulated cows (mean liveweight 365 kg) used during the previous year were randomly allocated to either a control group with no access to mineral, or given 0.75 g mineral • kg body weight^{-1} • day^{-1} intraruminally. The mineral mix was the same as given in 1988, and treatment animals were given free-choice access to the mineral for 30 days before the field study began. The 1989 study was conducted near Manti, Utah on rangeland dominated by *D. barbeyi* L. Huth. The study site was the same as reported by Pfister et al. (1988a,b). Briefly, this tall forb community was composed primarily of tall larkspur patches on snowdrift areas, and an open *Ribes-Agropyron* dominated site. The pasture was about 6 ha in size and was enclosed with an electric fence.

The study was conducted during an 18-day grazing period (9 to 27 August) when larkspur was in the flower and pod stages, and is generally most palatable to cattle (Pfister et al. 1988a,b). Procedures used in 1989 for dosing mineral, bite counts, water intake, alkaloid analysis, and ruminal fluid variables (i.e., dosing with Co-EDTA) were identical to those used during 1988. Bite counts were taken each day during all daylight hours when cattle were actively grazing. Water intake measurements and blood serum samples were taken near the beginning (14 August) and end (27 August) of the grazing period. Analysis of sera for sodium (Na), potassium (K), chloride (Cl), Ca, and magnesium (Mg) was done using standard procedures[4] at a regional medical center. Forage samples were from thirty 0.25-m^2 plots using 3 transect lines that bisected the pasture with 10 plots per line. The Co-EDTA solution contained 2520 and 2122 mg Co/liter when dosed at the beginning and end of the grazing period, respectively. In addition, pH of rumen samples was determined concurrently when samples were taken for Co analysis using an Orion portable pH meter with combination electrode.

Bite count data were analyzed using a repeated measures analysis of variance; model components were treatments, animals nested within treatments, and repeated measurements over the 18-day

[4]Monarch 2000 Analyzer

trial. Water intake, fluid passage variables and blood mineral components were also analyzed with the above model, except that the repeated measurements were taken at the beginning and end of the grazing period. Ruminal pH values were tested using the above repeated measures analysis, with an additional factor for hour post-dosing included in the model. All differences are reported at the $P<0.05$ level unless otherwise noted.

Results

Trial 1

Total larkspur consumption was low during the summer, with mean values from 1 to 2% for the various treatments. No differences due to mineral treatment were found for consumption of larkspur plant parts, total larkspur, or for forbs or grass (Fig. 1).

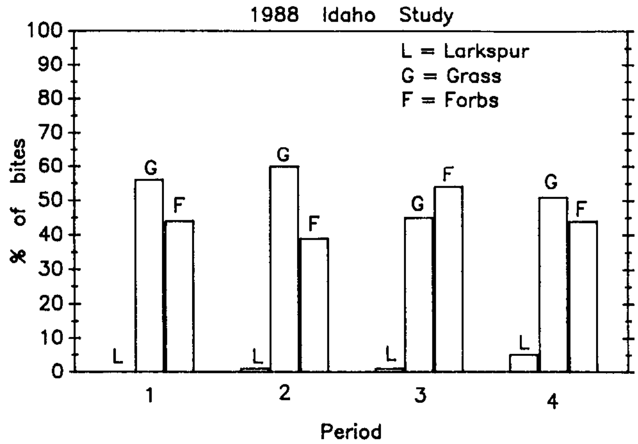

Fig. 1. Diet composition (% of bites) of cattle during summer, 1988 in southern Idaho. During 1988 larkspur consumption was examined during 4 phenological stages: bud, early flower, flower and pod, corresponding to periods 1 to 4, respectively.

Periods were different for every variable. Cattle ate about 5% total larkspur bites during the last period (pod stage) compared to less than 1% during the other 3 periods. The only treatment by period interaction was for bites of larkspur leaf, but these were always <5% of diets. Cattle diets were generally about 45% other forbs and over 50% grasses during the summer (Fig. 1).

Water intake differed among treatments (Table 2). The HIGH treatment increased water consumption compared to the CONT and LOW groups. Mineral supplementation at the HIGH level increased mean daily water intake by 30% over the CONT and LOW groups. Periods were different as water consumption increased during the last 2 periods. No period by treatment interaction was noted.

There was no period by treatment interaction for FPR, VOL, TOT or FOR (Table 2). No significant treatment effects were found for each variable. Period effects were noted, with periods 1 and 2 different from periods 3 and 4 for each variable (Table 2).

Calcium levels were not affected by treatment, but were higher on the last sampling date (Table 3). No treatment by period interaction was found for blood Ca.

The standing crop estimate for the beginning and end of each period is given in Table 4. Cattle generally had ample amounts of forage during each period. The amount of larkspur available for grazing declined over the summer, but was always a major component of the available forage.

There was a marked effect of maturity on total alkaloid concentration (TAC) of larkspur plant parts (Table 5). Immature larkspur stem, bud, and leaf material was highest in TAC, and levels declined as the season progressed. Flowers and pods maintained relatively high levels until the flowers matured into pods, and the pods shattered.

Trial 2

Total larkspur consumption did not differ between treatments, averaging 3% of bites over the grazing period (Fig. 2). No differences were found in consumption of larkspur plant parts. There was a

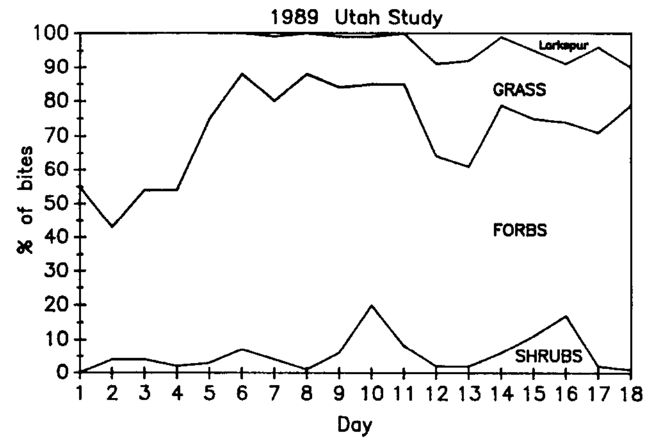

Fig. 2. Mean daily diet composition (% of bites) of cattle during 1989 in central Utah. During 1989 larkspur consumption was examined during an 18-day grazing trial when larkspur was in the flower and pod stages of growth.

Table 3. Blood serum levels (mg/dl: Ca, Mg; meq/liter: Cl, K, Na) in cattle receiving various mineral salt supplements in Idaho and Utah, 1988 and 1989.

Item	Mineral dose[a]				Date		
	0.0	0.5	1.0	Response[b]	7/22	8/5[c]	Response
Year 1							
Calcium	9.3	9.5	9.3	NS	9.3	9.6	P = 0.09
		0.0	0.75		8/8	8/25[c]	
Year 2							
Calcium		9.9	9.4	NS	9.2	10.1	**
Magnesium		2.4	2.3	NS	2.2	2.5	**
Chloride		104.2	104.6	NS	101.7	107.1	**
Potassium		4.8	4.8	NS	4.7	4.9	NS
Sodium		138.8	141.7	*	136.9	143.6	**

[a] $g \bullet kg$ body weight$^{-1} \bullet day^{-1}$
[b] NS=Non-significant at $P>0.05$, ** $P<0.01$, * $P<0.05$.
[c] In 1988, the study began on 15 June, but no beginning blood sample was drawn; In 1989 blood was drawn when the study began and ended.

Table 4. Standing crop [kg/ha (S.E.)] of vegetation on the study pasture during 1988 and 1989 in Idaho and Utah.

	Period							
Item	6/15 begin	– 6/24 end	6/29 begin	– 7/8 end	7/12 begin	– 7/21 end	7/26 begin	– 8/2 end
Year 1								
Grasses	246 (30)	270 (52)	334 (42)	276 (41)	280 (49)	287 (60)	525 (112)	313 (50)
Other forbs	446 (31)	438 (44)	416 (85)	533 (81)	418 (75)	245 (54)	338 (74)	277 (48)
Subtotal	692	708	750	809	698	523	863	590
Larkspur	731 (130)	624 (141)	676 (289)	523 (145)	537 (141)	559 (142)	479 (132)	436 (122)
Total	1423	1332	1426	1332	1235	1091	1342	1026
Year 2		8/8 – 8/25						
		begin	end					
Grasses		246 (62)	119 (26)					
Other forbs		1340 (301)	737 (97)					
Subtotal		1586	856					
Larkspur		957 (335)	729 (324)					
Total		2543	1585					

day effect, as animals consumed essentially no larkspur (<1%) during the first 11 days, then individual animals consumed from 0 to 33% total larkspur (mean of 7%) during the last 7 days of the study (Fig. 2). Consumption of grasses or forbs was not affected by treatment, with grass and forb consumption averaging 25 and 66% of bites, respectively.

Table 5. Total alkaloid concentration (% dry weight) of *Delphinium occidentale* and *D. barbeyi* plant parts during 1988 in southern Idaho, and 1989 in central Utah.

	Plant Part					
Date	Stem	Bud	Leaf	Flower	Flower & Pod[a]	Pod
D. occidentale						
6/16	1.38	3.10	2.45			
6/24	1.50	2.93	2.43			
6/30	0.75	2.42	2.11			
6/30			1.39	1.94		
7/15	0.38		1.59	1.83	1.49	
7/22	0.46		1.21	1.56	1.59	
8/02	0.40		1.02			1.51
D. barbeyi						
8/09	0.50		1.18	0.84		
8/18	0.43		0.92			1.01
8/26	0.27		0.39			0.98

[a]Reproductive raceme with some residual flower blossoms and some seed pods.

Water consumption was not different (Table 2). There was a date effect but no date by treatment interaction. Water intake increased over 50% from the first measurement made on 14 August compared to 27 August.

Fluid passage rate, TOT and VOL were not affected by mineral treatment (Table 2). FOR was increased due to mineral supplement (Table 2). No treatment × period interaction was found for any variable. FOR and VOL decreased at the end of the trial; there was no period effect on FPR and TOT. No treatment effect on ruminal pH was found (data not shown). As expected, hour after dosing with Co-EDTA did affect pH. As animals grazed throughout the day, pH declined (6.4 to 5.8) as carbohydrate-rich substrate was ingested.

No date × treatment interactions were found for any blood variable. Na levels were increased by mineral supplementation (Table 3). There was a date effect for all variables except K.

Forage availability at the beginning and end of the study is given in Table 4. Grasses, forbs and total forage declined during the study period, while total larkspur did not decline substantially.

Alkaloid concentration of *D. barbeyi* plant parts is given in Table 5. Leaves declined substantially in TAC during the trial, while flower and pod TAC remained relatively constant.

Discussion

The 1988 Idaho study was conducted during a severe drought, and the pasture only received 27 mm of precipitation from 15 June to 5 August. During 1989 the drought was less severe in central Utah, but only 28 mm of rain were received during the study period, compared to 8 cm at this site during the same 3 weeks in 1987. The larkspur was apparently of low palatability during both summers, and we speculate that palatability may have been influenced by precipitation patterns. In previous studies (Pfister et al. 1988a,b) cattle have eaten from 10–20% of their diets as larkspur. Water stress increases alkaloid concentration in many species (Gershenzon 1984), and the bitter taste of alkaloids is presumed to deter grazing by herbivores (Bate-Smith 1972). The total alkaloid concentration we found in *D. occidentale* during 1988 was lower than noted by Ralphs et al. (1988) and Olsen (1983), but was similar to values reported by Laycock (1975) and Williams and Cronin (1966) for plants collected at a similar elevation. The alkaloid concentration of *D. barbeyi* leaves was 25 to 50% higher than noted in August for flowering plants at this site in earlier studies (Pfister et al. 1988a,b).

Following the only major storm during June, 1988, one heifer (HIGH group) consumed a large amount of larkspur during the night, and at daybreak and throughout the morning, she alternated between periods of sternal recumbency and muscular tremors while standing, classic signs of larkspur intoxication (Olsen 1978). Previous summers experience with *D. barbeyi* in Utah has shown that cool, wet weather apparently triggers increased larkspur consumption (Pfister et al. 1988a,b), perhaps due to changes in levels of individual alkaloids (Pfister, unpublished data).

Previous research on the question of mineral salt supplementation to reduce larkspur consumption or cattle deaths has not been conclusive (Knowles 1974, Logan 1973). Results from our study must also be viewed with caution with respect to ingestion of larkspur, due to the low levels of consumption. The low level of larkspur consumed was unexpected in light of previous experience, but when cattle did consume greater quantities during the pod stage, mineral salt supplement had no influence on the amount of larkspur selected. Based on toxicity tests of larkspur collected during August, 1989, at the Utah site, we estimate that animals could have consumed 25–30% of their diets (dry weight) as larkspur with little danger of acute intoxication. The previously reported LD_{50} (median lethal dose) is near 2.5 g/kg body weight (Olsen 1978), and material collected during 1989 and dosed at >5 g/kg body weight produced only slight muscular tremors in cattle (Pfister, unpublished data).

The levels of mineral salt given to cattle in this study greatly exceed the requirements for Na (NRC 1984). Further, free choice ingestion of mineral would rarely approach the treatment levels we used (Cohen 1987). When evaluating mineral supplements when consumption is unknown, Ellis et al. (1988) recommend using an intake figure of about 50 g • $head^{-1}$ • day^{-1}, which would correspond to 0.18 g/kg body weight for our 1988 study. Other cattle grazing with the experimental animals in 1988 and allowed to consume mineral for 30 min each day consumed 0.2 g mineral/kg body weight (Pfister, unpublished data). Knowles (1974) reported an average daily trace mineral salt consumption of about 0.25 g/kg body weight for free-ranging cows on a larkspur-infested range in Idaho.

Profiles of blood minerals have been used extensively to identify dietary causes of poor production (Maas 1983). Blood values for Ca, Mg, Cl, K, and Na were within normal ranges, indicating that animals were within homeostatic limits.

Water intake was increased by 30% during 1988 by the addition of the HIGH mineral level. No differences were noted in 1989, but the mean daily maximum temperature was 13° C lower than during 1988, and water consumption was low. Others have noted increases in water intake in cattle in response to high mineral salt feeding (Croom et al. 1982, Rogers and Davis 1982, Schneider et al. 1988). Schneider et al. (1988) and Rogers and Davis (1982) reported increases in FPR in cattle receiving high mineral salt diets. However, most studies on the use of mineral salts have been conducted to study effects of buffers on high concentrate diets, and results have been less consistent with forage diets. Addition of large amounts of mineral salt can result in hypertonic rumen fluid and decreased ruminal fermentation (Durand and Komisaraczuk 1988).

We saw no indications of increased FPR, VOL or TOT with increased mineral salt supplementation in grazing cattle. The increase in FOR during 1989 resulted from slight, but insignificant increases in both FPR and VOL. It is unclear whether this increase has pharmacological significance for animals consuming larkspur alkaloids. The increase in water intake we observed during 1988 was apparently not sufficient to alter ruminal fluid kinetics. Funk et al. (1987) speculated that increased water consumption resulting from elevated ambient temperatures may influence FPR in grazing cattle, but Harrison et al. (1975) found that infusions of water into the rumen did not alter FPR.

This study is limited because only 1 mineral salt supplement was tested. Obviously there are a large number of potential mineral supplements (type × dose) that could be examined, and we have no indication of the generality of this study to other combinations of minerals. We tested this mineral salt mix because of widespread use of this formulation throughout Utah, Idaho, and Colorado.

This specific mineral salt supplement may have little impact on ingestion of tall larkspur by grazing cattle. Other factors such as drought stress likely have a much greater impact on acceptability of larkspur to cattle. Moreover, we found little evidence to support the idea that mineral salt supplement will lower animal susceptibility through changes in ruminal fluid kinetics. We conclude that livestock producers should consider mineral salt supplementation in relation to animal requirements and forage deficiencies, and use caution when supplementing mineral for the sole purpose of reducing losses to poisonous plants.

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