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Research in Beef Cattle Nutrition and Management



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RESEARCH IN BEEF CATTLE NUTRITION AND MANAGEMENT

Robert J. Raleigh and Joe D. Wallace 1/

NUTRITIVE VALUE OF RANGE FORAGE AND ITS EFFECT
ON ANIMAL PERFORMANCE

Three nutrients that deserve major consideration for livestock production from range forage are protein, energy, and phosphorus. Range forage is generally deficient, except during early growth, in these three nutrients for optimum livestock production. These nutrients decrease with maturity of the forage.

Nutrients such as copper, iron, and selenium are generally associated with specific deficiency or toxicity areas. Many of the problem areas in Oregon have been delineated, and from time to time others are discovered. Once problem areas are revealed, measures can usually be taken to adjust for them.

The optimum time to harvest range forage, from the standpoint of livestock performance, is as follows: (1) during May, low elevation ranges (3,000 feet or over), (2) during June, intermediate elevation ranges (4,000 feet), and (3) during July, high elevation ranges (5,000 feet or over). By this date a stage of growth is reached so that total forage production is attained and forage still has adequate quality for good livestock production. Since harvesting at this time is impractical, the best approach is to determine forage quality at all times during the grazing season and manage livestock to obtain the greatest return. Nutrient content, digestibility, and voluntary intake by grazing animals are necessary considerations for evaluating range forage.

A major portion of the work on range livestock at the Squaw Butte Experiment Station has been directed toward these objectives during the past several years. The work was conducted on a sagebrush-bunchgrass range area and is concerned with both native grasses and crested wheatgrass.

Experimental Procedures

Digestion trials were conducted with steers and wethers on native and introduced grasses at various times during the grazing season for a period of several years. Protein, energy, cellulose, and dry matter digestibility of native and seeded range forage were determined at weekly or bi-weekly intervals.

1/ Robert J. Raleigh is Associate Professor of Animal Nutrition, and Joe D. Wallace is Assistant Professor of Animal Science, Oregon State University.

Forage samples were obtained by grazing with rumen-fistulated animals and by clipping. Animals used in this work were fistulated by making an opening into the rumen and closing the opening with a removable plug. Fistulated animals were gentle, easy to work with, and grazed normally in association with other cattle with no apparent discomfort. Samples from grazing animals were obtained by completely evacuating the rumen of fistulated steers and permitting the steers to graze with normal animals for one hour. Rumen contents were then mixed and a sample removed. Most clipped samples were obtained by observing grazing animals and attempting to clip the same portions of species that were grazed by the animals.

Intake studies were conducted on grazing animals at different times during the season to determine the effect of forage quality on intake, and also to determine the effect of protein and energy supplements on forage intake. To date, these studies have all been conducted with animals on crested wheatgrass, but there is no evidence that the data are not applicable to native grasses. Forage intake was determined by a method developed by Oregon State University and the Squaw Butte Experiment Station. This method involves daily administration to each animal of a known amount of chromium oxide (Cr_2O_3) and collecting fecal samples for the determination of Cr_2O_3 and nitrogen. Cr_2O_3 passes through the digestive tract unchanged and is recovered in the feces. By using a formula of the ratio of nitrogen in the forage and feces, and the ratio of Cr_2O_3 in feces to the known amount administered, forage intake can be calculated.

Once forage intake is determined, intake of specific nutrients used for animal production can be calculated by sampling the forage and using digestion trial data for the particular time of the grazing season. Nutrient requirements of various classes of livestock for different levels of production have been established by many years of research, and while additional knowledge may change some of these, current requirements published by the National Research Council are within the levels of production expected from animals on range forage. By knowing the nutrient intake from range forage and the requirement for particular levels of production, one can determine the age or class of animals that make the most effective use of range forage at different times during the grazing season and whether or not supplementation would be economical at certain times of the year. Economical livestock production cannot be obtained, even through supplementation, if a shortage of range forage limits voluntary intake of the grazing animal.

Observations

Nutrient content. Nutrient content, as measured by chemical analysis, of forages at various times during the grazing season is presented in Table 1. Lignin, a relatively indigestible plant component, has been included in this table to show the relationship between lignin, protein, and energy. As protein and energy decrease with plant maturity, lignin usually increases and makes the forage less digestible. These data represent averages of several analyses covering at least two years and, in some cases, up to six years. While values were not always alike from year to year, general trends of declining forage quality during grazing were similar. Variation in amounts and time of precipitation during the grazing season caused some fluctuation. Differences between years were greater than differences between forage in any one year, so native and crested wheatgrass forage have been averaged.

Table 1. Nutrient concentration of range forage during the grazing season.

Date	Crude protein	Cellulose	Phosphorus	Lignin	Crude fiber
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
May 1	18.8	23.9	0.22	4.18	19.7
May 15	17.7	25.0	0.20	4.30	20.5
May 29	12.0	26.6	0.19	4.61	21.6
June 12	10.2	27.7	0.18	5.60	22.6
June 26	8.6	28.8	0.17	6.62	23.3
July 10	7.4	29.6	0.16	6.93	23.9
July 24	6.3	30.1	0.15	7.20	24.6
August 7	5.3	30.4	0.14	7.42	24.9
August 21	4.2	30.5	0.12	7.56	25.2
September 4	3.3	30.4	0.11	----	----
September 18	2.9	30.4	0.11	----	----

Digestion trials. Digestibility data from native range and crested wheatgrass forage appear in Table 2. Digestibility of various nutrients decreased with each later stage of growth. These data were averaged over several years, as was the chemical data. Nutrients available for animal production decreased with later stages of growth at a more rapid rate than of nutrients in the forage, because of decline in digestibility.

Forage intake. Forage intake studies have been limited to crested wheatgrass. These should be applicable to native forage as well, since chemical content and digestibility values of the forage are comparable. Also, studies conducted at the station showed that gains of yearling cattle on crested wheatgrass were equal to gains of those on native range at any time during the grazing season. Intake studies were conducted the third week in June, July, and August with yearling heifers, supplemented and nonsupplemented, on crested wheatgrass (Table 3). Intake was highest per unit of body weight during July. Supplementation at low or high levels during June increased

Table 2. Average digestibility of protein, energy, cellulose, and dry matter of range forage during the grazing season.

Date	Crude protein	Cellulose	Gross energy	Dry matter
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
May 29	65.0	70.0	63.0	62.0
June 12	64.5	68.5	63.0	62.0
June 26	63.5	59.8	62.0	59.0
July 10	58.2	56.1	58.0	57.0
July 24	44.0	54.0	57.0	52.0
August 7	36.5	53.2	51.0	49.0
August 21	28.5	52.0	48.0	48.0
September 4	26.0	52.0	46.0	48.0

forage intake. The low level of supplementation had no effect on intake during July and August; however, the higher level apparently inhibited forage intake during these two months.

Animal production. Performance of animals on range forage follows the same declining pattern during the grazing season as it does on most forage nutrients. Gains by yearling cattle are 2.0 pounds or more during May and June, 1.5 pounds or less during July, and less than 1.0 pound thereafter. Gains by suckling calves are 1.75 pounds or more during May and June, 1.5 pounds or less in July, less than a pound in August, and relatively no gain after the first of September. Gains presented in Figure 1 are average gains from the Squaw Butte cattle over several years. Actual gain will vary from year to year. In 1963 yearling cattle on the station gained 1.3 pounds on crested wheatgrass without supplementation in mid-August, while in 1964 yearling cattle on this range averaged 0.78 pounds per day from July 15 to August 12.

Supplementation of protein and energy, starting about mid-June and lasting until about mid-August, will give an economic return. The supplement should supply the difference between that provided by the forage and the requirement for about 2 pounds daily gain for yearlings. After mid-August, forage nutrients are usually low enough so that more than half of the required nutrients need to be supplied by supplementation. When forage quality is adequate to provide for 1-pound daily gain, supplementing for a 2-pound gain would be

Table 3. Body weight, daily gains, total intake, supplemental intake, and forage intake of yearling heifers on crested wheatgrass.

Date Treatment	Number of animals	Body weight	Daily gain	Total intake <u>1/</u>	Supple- ment <u>1/</u>	Forage intake <u>1/</u>
		<u>lb.</u>	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>
6/16 - 6/20						
No supplements	3	638	1.84	12.80	----	12.80
Low supplements	3	637	1.94	15.79	0.75	15.04
High supplements	3	638	2.02	17.17	1.45	15.99
Average	9	638	1.93	15.25	----	14.61
7/15 - 7/19						
No supplements	3	682	1.56	24.56	----	24.56
Low supplements	3	682	1.75	23.88	1.30	22.58
High supplements	3	685	1.61	20.58	1.90	18.68
Average	9	683	1.64	23.01	----	21.94
8/15 - 8/19						
No supplements	3	720	1.32	22.20	----	22.20
Low supplements	3	738	2.29	25.43	2.70	22.73
High supplements	3	737	1.84	22.90	3.65	19.25
Average	9	732	1.82	23.51	----	21.39

1/ Supplements were equal parts of rolled barley and cottonseed meal; all intake values are on a dry-matter basis.

economical. Supplementing for higher than 2 pounds of daily gain does not appear to be economical, as higher levels of supplementation cause a decrease in voluntary forage intake.

Supplementing with a low level of energy in May and early June has increased gains from 2.0 to 2.25 pounds to 2.5 to 2.8 pounds in studies conducted at the station. Apparently, intake of this high-moisture forage is not adequate to supply necessary energy for this type of gain. More work needs to be conducted to establish levels of supplementation and to determine the effect of this high rate of gain on subsequent summer gain.

Suckling calves make little or no gain when left with range cows after early September. Possibilities of increasing weaning weights are quite limited. Creep feeding, where practical, can be economical. Earlier

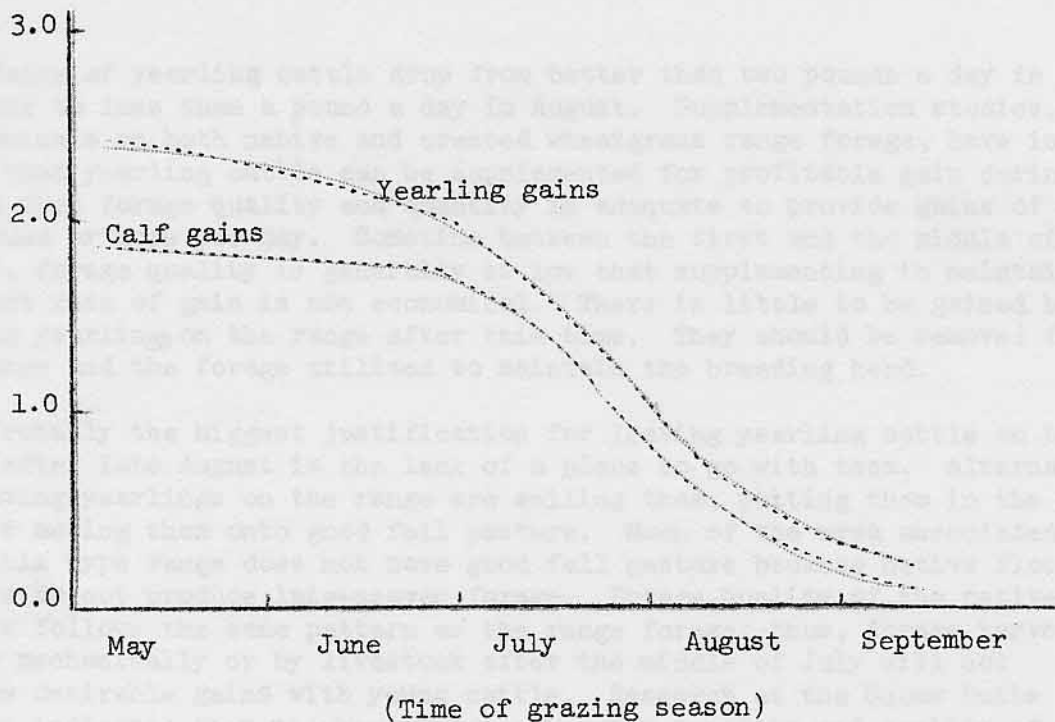


Figure 1. Average daily gains of yearling cattle and suckling calves during the summer grazing period.

calving to get larger calves on range during the 60- to 90-day period of high quality feed may offer a means of weaning heavier calves. There is little to be gained, other than saving some labor, by leaving calves on range after the first of September. Our research has shown that calves weaned in early September and put on winter feed will return more to the rancher than those weaned later.

Results of these studies indicate that to obtain the highest livestock production from a unit of rangeland, animals that are to be sold should be removed from range sometime during August. At this time forage quality is so low that animal gains are minimal. This would leave remaining forage for maintenance of the breeding herd and offer the flexibility needed to adjust for good and poor years of range feed.

YEARLING CATTLE GAINS ON NATIVE RANGE FORAGE AND BUNCHED HAY

Gains of yearling cattle drop from better than two pounds a day in May and June to less than a pound a day in August. Supplementation studies, with animals on both native and crested wheatgrass range forage, have indicated that yearling cattle can be supplemented for profitable gain during the period when forage quality and quantity is adequate to provide gains of about one pound or more per day. Sometime between the first and the middle of August, forage quality is generally so low that supplementing to maintain a constant rate of gain is not economical. There is little to be gained by leaving yearlings on the range after this time. They should be removed from the range and the forage utilized to maintain the breeding herd.

Probably the biggest justification for leaving yearling cattle on the range after late August is the lack of a place to go with them. Alternatives to leaving yearlings on the range are selling them, putting them in the feedlot, or moving them onto good fall pasture. Much of the area associated with this type range does not have good fall pasture because native flood meadows do not produce late-season forage. Forage quality of the native meadows follows the same pattern as the range forage; thus, forage harvested either mechanically or by livestock after the middle of July will not produce desirable gains with young cattle. Research at the Squaw Butte Station indicates that the best balance between quantity and quality of forage for livestock production is reached between July 1 and July 15. The purpose of this study was to compare gains of yearling cattle grazing all season long on the range, with gains from yearlings grazing range forage in early season and bunched native hay in late summer and fall.

Experimental Procedure

Forty-five yearling animals were stratified by weight to 3 groups of 15 each (Table 4). Each group was randomly allotted to one of three range-grazing treatments: (1) range forage alone, (2) range forage plus adequate nutrient supplementation to provide for maintenance and gain of 2.25 pounds, and (3) the same as treatment 2 except that additional energy was supplemented during the time the moisture content of the forage was high (about May 20 to June 15). The supplements required for maintenance and 2.25 pounds of gain were calculated through the use of previous data based on the chemical content of this forage at various stages of growth during the grazing season. The supplements fed while cattle were on range are shown in Table 5. Cottonseed meal and rolled barley were the supplemental sources of protein and energy, respectively. The animals were group-fed their supplements daily in troughs located near the water.

Five animals from each supplementation treatment were taken off the range and put on bunched meadow hay on July 22 and August 12. Each group of animals grazed in separate 160-acre native range pastures, but during the time they were on bunched hay, the animals were in the same field. The heifers had access to water, salt, and bonemeal during the entire trial. They were weighed periodically, with all weights taken after an overnight restriction from food and water.

Table 4. Design of the experiment

Bunched hay	Supplement on range		
	None	June 15 to August 12	May 20 to August 12
None	5 <u>1</u> /	5	5
July 15	5	5	5
August 15	5	5	5

1/ Number of animals.

Table 5. Daily supplements fed per head for various dates while cattle were on native range (treatment 1 received range forage only)

Date	Treatment			
	2		3	
	Barley	Cottonseed meal	Barley	Cottonseed meal
	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>
5/20 - 6/1	----	----	1.00	----
6/2 - 6/8	----	----	0.75	----
6/9 - 6/15	----	----	0.50	----
6/16 - 6/22	----	0.50	0.25	0.50
6/23 - 6/29	0.25	0.65	0.25	0.65
6/30 - 7/6	0.25	0.80	0.25	0.80
7/7 - 7/13	0.35	0.90	0.35	0.90
7/14 - 7/20	0.45	1.00	0.45	1.00
7/21 - 7/27	0.60	1.10	0.60	1.10
7/28 - 8/3	0.90	1.20	0.90	1.20
8/4 - 8/10	1.20	1.35	1.20	1.35
8/11 - 8/12	1.50	1.50	1.50	1.50

Observations

Average daily gains of the animals during the supplemental period are presented in Table 6. Body weight gains for supplemental treatments on range followed the same pattern as in previous years. The yearlings receiving energy supplement in the early part of the season gained 0.35 pounds more than those unsupplemented. This higher rate of gain in early season did not affect rate of gain later in the season. Animal response from supplements during July and early August was lower than in previous years, yet gains were significantly higher in supplemented than in nonsupplemented groups.

Table 6. Animal gains for time intervals and supplemental treatments on range

Treatment	Time interval			Average
	5/20 to 6/17	6/17 to 7/22	7/22 to 8/12	
	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>
No supplement	2.35	1.45	0.90	1.62
Supplement (6/17-8/12)	2.23	1.75	1.34	1.77
Supplement (5/20-8/12)	2.64	1.86	1.69	2.08
Average	2.41	1.67	1.31	1.83

Gains of animals by periods for the comparison of bunched hay and native range forage appear in Table 7. Animal performance was poor during the adjustment from range feed to bunched hay. However, after adjusting to the hay, the group which was on bunched hay from July 22 gained 0.47 pounds more per head daily by October 1 than did the animals on range forage during that time. The animals that were moved to bunched hay on August 12 gained 0.18 pounds per day more than those on range forage during the period from August 12 to October 1. Range forage quality was above average as a result of late season rains, and cattle gains from range feed alone were above normal during this period. Greater differences between supplemented and unsupplemented cattle and between those moved to bunched hay and those remaining on range should be expected in years with less summer rain.

Results of this study indicate that yearling cattle will do better in late July, August, and September on good quality, bunched meadow hay than on range forage. There is a depression in gain for about the first 2 to 3 weeks while the animals are adjusting to the feed change, which indicates that putting animals on bunched hay for a short time would not be profitable. It would be better to sell yearlings directly off the range rather than move them to bunched hay for a short period.

Table 7. Animal gains for different time intervals from range forage and bunched hay

Date animals went on bunched hay	Time interval			Average
	7/22 to 8/12	8/12 to 9/2	9/2 to 10/1	
	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>	<u>lb.</u>
7/22	0.32	1.41	1.78	1.23
8/12	----	0.40	1.48	0.94
Native range (all season)	1.04	0.56	0.76	0.76
Average	0.68	0.79	1.34	0.99

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PERFORMANCE OF CALVES FED VITAMIN A WITH BALED AND CHOPPED MEADOW HAY

Processing of various roughages into pellets and wafers for livestock feeding has been investigated quite thoroughly. At present, advantages of pelleted roughages are usually offset by processing costs. Information about feeding the same hay in long and chopped forms is more limited. Conceivably, chopping of coarse, stemmy hay should reduce selection and waste and perhaps increase intake. Selection and waste are usually of less concern with grass or fine-stemmed hay than with coarse-stemmed hay.

Vitamin A supplementation for beef cattle has received considerable attention in recent years. In many cases, vitamin A feeding is being promoted as a "cure-all" for poor performance or almost any cattle disease or disorder that is not immediately recognized. Few, if any, such uses of vitamin A are substantiated by research. Feedlot cattle receiving high concentrate rations require additional vitamin A, but in other instances blanket recommendations for vitamin A feeding are open to question.

The work reported in this paper was conducted to compare performance of weaner calves fed long (baled), coarse-chopped (4- to 6-inch lengths), or fine-chopped (1- to 2-inch lengths) meadow hay. The effect of supplying additional vitamin A was also studied.

Experimental Procedure

Thirty-six Hereford steer calves with an average weight of 400 pounds were stratified by weight and randomly allotted to 6 lots of 6 animals each. Baled, coarse-chopped, and fine-chopped meadow hay were each fed to two. One lot of calves fed each form of hay received 20,000 international units (I. U.) of stabilized vitamin A per head daily while the other lot received no vitamin A supplementation. In addition to hay, all lots were fed 2 pounds of rolled barley and 1 pound of cottonseed meal per head daily.

The different forms of hay for respective treatments were weighed into sheltered mangers daily and refusals were weighed weekly. Barley and cottonseed meal were fed daily in feed troughs, and vitamin A was mixed with the cottonseed meal for lots receiving this treatment. Water, salt, and a mineral mix were available to the animals at all times. During the 120-day study, each animal was weighed periodically, following an overnight shrink. The meadow hay fed in this trial came from the same meadow and was harvested on the same day. The hay contained 8.8% crude protein and over 20 milligrams of carotene per pound.

Observations

Form of hay. No differences in rate of gain were observed among the calves fed different forms of hay, although calves fed fine-chopped hay consumed more hay than those fed coarse-chopped or baled hay (Table 8). The calves fed baled hay made more efficient gains than those fed either form of chopped hay. Work from other stations has shown that chopping or grinding roughages may increase voluntary consumption but generally decreases digestibility. The lower digestibility of chopped hays probably accounts for the comparable gains among calves fed chopped and long hay in this trial, even though consumption was greater in chopped-fed lots.

Hay refusals were largest for calves fed fine-chopped hay and smallest for those fed baled hay. The protein content of refused portions of both forms of chopped hay was higher than the protein content of the hay fed initially, while that of baled hay was the same as it was initially. Chopping meadow hay may grind some of its high quality constituents into a fine unpalatable state.

Vitamin A feeding. Supplying additional vitamin A in the rations had no material effect on rate of gain or consumption, but there was a trend for improved feed efficiency in the lots receiving vitamin A (Table 8). Rations fed in this trial furnished over 200 milligrams of carotene per steer daily, which far exceeds current recommended requirements suggested by the National Research Council. There is considerable evidence that, unless some interfering factor is present, cattle receiving rations containing sufficient carotene have no difficulty in meeting their vitamin A requirement.

During the first month of the trial, a number of calves developed pink-eye. Vitamin A feeding was of no apparent benefit in correcting pink-eye, nor did it exert other beneficial side effects during the study. At the close of the trial, liver vitamin A stores were higher in calves fed supplemental vitamin A. This would be of little value for animals going on green grass in the spring.

Table 8. Average performance of calves fed different forms of meadow hay with and without vitamin A supplementation

Vitamin A supplement (I. U.)	Form of hay					
	Baled		Coarse- chopped		Fine- chopped	
	0	20,000	0	20,000	0	20,000
Calves per lot	6	6	6	6	6	6
Initial weight, lb.	410	390	397	407	399	407
Final weight, lb.	572	559	554	576	558	570
Daily gain, lb.	1.35	1.41	1.31	1.40	1.32	1.36
Daily hay consumed, lb.	10.8	10.3	10.5	11.1	11.1	11.3
Daily hay refused, lb.	0.38	0.40	0.56	0.58	0.88	0.70
Feed per pound gain, lb.	10.2	9.4	10.3	10.1	10.7	10.5

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VITAMIN A NUTRITION AND PERFORMANCE OF HEREFORD HEIFERS FED DIFFERENT LEVELS OF NITRATE

The factors responsible for accumulation of high nitrate levels in plants are not fully understood. This capacity seems to vary widely among species and is evidently related to soil conditions, climatic factors, and fertilization practices. Meadow hay analyses from this area have revealed very low concentrations of nitrate, although many conditions present on wet meadows are favorable for increased nitrate accumulation in plants.

Feeds containing more than 1.5% nitrate are considered potentially toxic for beef cattle. Some recent investigations have related nitrate levels below 1.5% to certain animal disturbances such as decreased feed consumption and rate of gain, reduction in conversion of carotene to vitamin A, and increased methemoglobin formation. Nitrate levels as low as 0.5% are considered possible sources of trouble under some conditions. Nitrate appears to be more harmful to cattle consuming low concentrate rations than to those receiving high energy rations.

The purpose of the work summarized in this report was to study the influence of different levels of nitrate in meadow hay rations for calves and yearlings.

Experimental Procedure

Eighteen weaned heifer calves and 18 long yearling heifers were stratified by weight within each age group and randomly allotted to experimental treatments for a 100-day individual feeding study. The treatments were 0.0, 0.6, and 1.2% nitrate in the total ration. One-half of the animals receiving each level of nitrate was fed 20% concentrate rations, while the other half was fed 40% concentrate rations. The roughage portion of all rations was coarsely chopped meadow hay; the concentrate portion was processed into 3/8-inch pellets. Hay and concentrates were thoroughly mixed in individual mangers prior to feeding each day. Calcium nitrate was included with the pelleted portion of the rations to achieve desired levels of nitrate intake for calves on each treatment.

Animals used in this study were removed from summer range in October and fed a low carotene ration for approximately 100 days before they were allotted to experimental treatments. The pretreatment ration consisted of sun-bleached meadow hay plus a supplement of barley and cottonseed meal. The purpose of the pretreatment period was to lower vitamin A stores in order to provide a wider range in which to study the conversion of carotene to vitamin A.

Blood and liver biopsy samples were taken from animals when they came off summer range, at the end of the pretreatment period, and again when the study was terminated. Carotene, vitamin A, and methemoglobin analyses were conducted on all blood and liver samples. Each animal was weighed at periodic intervals following an overnight shrink.

Observations

Feed consumption (Table 9) and daily gain (Table 10) were not significantly influenced by nitrate level in the diet. Animals fed diets containing 40% concentrate consumed more feed and gained at a faster rate than those fed 20% concentrate diets.

Table 9. Average feed consumption of calves and yearlings fed different nitrate and concentrate levels

Treatment		Animal class	
Concentrate	Nitrate	Calf	Yearling
<u>%</u>	<u>%</u>	<u>lb.</u>	<u>lb.</u>
20	0.0	10.5	15.9
	0.6	10.3	17.7
	1.2	10.6	19.0
40	0.0	11.4	19.1
	0.6	10.8	19.4
	1.2	11.3	19.4
Average feed consumption		10.8	18.4

Table 10. Average daily gain of calves and yearlings fed different nitrate and concentrate levels

Treatment		Animal class	
Concentrate	Nitrate	Calf	Yearling
<u>%</u>	<u>%</u>	<u>lb.</u>	<u>lb.</u>
20	0.0	0.64	0.55
	0.6	0.71	0.69
	1.2	0.60	0.65
40	0.0	1.02	1.01
	0.6	0.90	1.06
	1.2	1.12	1.22
Average gain		0.83	0.81

When the animals were removed from summer range, liver vitamin A stores averaged 140 I.U./gram for calves and 232 I.U./gram for yearlings. After 100 days on the bleached hay ration, these values had declined to an average of 51 for calves and 100 for yearlings. The level of nitrate fed to the heifers had no apparent effect on conversion of carotene to vitamin A. Over the nitrate feeding period, control animals had an average increase in liver vitamin A storage of 69 I.U./gram, while those fed 0.6% and 1.2% nitrate averaged increases of 84 and 71, respectively. The increase in liver vitamin A during this study was considerably greater for calves (101 I.U./gram) than for yearlings (48 I.U./gram).

The carotene and vitamin A contents of blood plasma were essentially the same for each class of animals receiving different levels of nitrate, but they were higher in yearlings than in calves. Methemoglobin in blood was not related to treatments.

On the basis of this study, it would appear that nitrate levels up to 1.2% in meadow hay rations will not adversely affect beef cattle performance or vitamin A nutrition. Meadow hay produced in this area with normal fertilization would contain nitrate levels far below the 0.6% level fed in this study.