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Range Forage and Animal Nutrition[1,2]

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Optimum-range livestock production can be achieved only through compatible livestock and forage management. The first requirement in developing a range livestock and forage management program is a quantitative and qualitative inventory of forage resources. This means an inventory of range forage nutrients at specific times during the grazing season. Only after the relative seasonal availability of nutrients is known can livestock be managed to obtain a maximum return from the available forage resources.

Research reported herein was conducted on an eastern Oregon sagebrush-bunchgrass area, the Squaw Butte Experiment Station. The area, with a mean elevation of 1,375 m annually, averages about 30 cm precipitation, two-thirds of which occurs as snow in winter and the remainder as rain during the growing season of April, May, and June. Research involved not only native vegetation, but also introduced species, primarily crested wheatgrass (*Agropyron desertorum*). These studies are mainly concerned with the management of both range and livestock during the spring, summer, and fall. The majority of the forage on winter range is low-quality mature grasses on which livestock can be managed primarily for maintenance.

The principal objective of these studies was to evaluate forage periodically throughout the grazing season and adapt these data to animal requirements to establish a program that would permit maximum livestock production from the forage. It is not possible to harvest all range forage at a time when it will give maximum animal production. If seasonal forage quality is known, however, management

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programs utilizing the proper class of animal can be developed to give the greatest return from the forage.

Dry matter intake, digestible energy, and digestible protein are the major factors concerned in production from ruminants grazing range forage. Digestible protein is usually the first nutrient limiting production, followed by digestible energy; concentration of both nutrients decreases rapidly as the plants mature, as does animal voluntary dry matter intake. Dry matter intake is often limited by total feed available, terrain or inaccessibility of range forage, and palatability; however, in the early part of the growing season high moisture content of the forage possibly does limit forage dry matter intake. While minerals, particularly phosphorus, are limiting in range forage, these are easily supplied with a salt supplement. This is a recognized need and a generally accepted practice. The work reported here is mainly concerned with protein and energy of the forage and the extent to which they meet the requirements for livestock production.

The precipitation pattern permits only one growth cycle, resulting in all forage species maturing at about the same time with little difference in quality between species. In fact, more difference in quality is found at a given date between years within a given species than between species within a given year. Data in tables and figures are averages, although much of the information was obtained on single species. Forage samples were collected by both hand plucking and rumen evacuation methods described by Cook (1964) and forage intake and digestibility were determined by fecal index and indicator methods as described by Harris et al. (1967). *In vitro* digestibility was determined as reported by Wallace, Rumburg, and Raleigh (1965).

I. FORAGE EVALUATION: CHEMICAL

Range forage was periodically sampled during the grazing season from late April to November over the course of several years. Samples of individual species were taken by clipping, grazing was simulated by hand-plucking on mixed species, and fistulated animals were grazed on single native and introduced species. Table 1 shows the chemical content and *in vitro* cellulose digestibility data obtained on two desirable native forage species and crested wheatgrass at various times during the grazing season. These data indicate the decline in nutritive value of the forage beginning in late April, when only leaves were ex-

Table 1—Chemical composition and *in vitro* cellulose digestion of range grasses at various stages of growth during 1959 and 1960 (dry matter basis)

Species and date	Growth stage	Air dry matter	N	Ether extract	Crude fiber	P	Ca	In vitro cellulose digestion
					%			
A. spicatum (Bluebunch wheatgrass)								
4-30-59	Pre-boot	31	3.1	1.2	21	0.24	0.26	73
5-11-60	Pre-boot	34	2.5	2.0	20	0.22	0.23	72
5-18-59	Boot	36	2.5	1.7	22	0.23	0.27	67
5-23-60	Pre-boot	38	2.3	1.5	21	0.19	0.21	66
6-2-59	Head	42	1.9	2.2	23	0.18	0.25	62
6-2-60	Boot	35	2.1	2.4	22	0.23	0.25	71
6-16-59	Early flower	43	1.6	2.4	26	0.18	0.22	55
6-16-60	Head	44	1.6	2.5	27	0.15	0.20	51
7-1-59	Early seed	60	1.2	3.3	27	0.18	0.16	47
7-15-59	Mature	69	0.9	2.6	30	0.13	0.19	37
8-5-60	Mature	88	0.8	4.3	25	0.23	0.28	44
K. cristata (Junegrass)								
4-30-59	Pre-boot	33	3.1	1.8	20	0.26	0.31	74
5-11-60	Early boot	30	2.4	2.9	21	0.25	0.24	77
5-18-59	Early head	34	2.1	2.2	21	0.23	0.28	71
5-23-60	Early head	32	2.0	2.2	21	0.20	0.27	71
6-2-59	Head	40	1.8	2.6	24	0.22	0.27	70
6-2-60	Head	35	1.8	3.0	25	0.23	0.26	77
6-16-59	Flower	40	1.5	2.8	27	0.21	0.27	66
6-16-60	Flower	40	1.4	3.0	28	0.16	0.23	58
7-1-59	Seed stage	58	1.4	4.9	23	0.23	0.31	61
7-15-59	Mature	70	1.4	4.9	22	0.20	0.27	61
8-5-60	Mature	85	1.0	4.2	25	0.19	0.21	64
A. desertorum (Crested wheatgrass)								
4-30-59	Pre-boot	30	2.8	2.0	15	0.22	0.21	76
5-11-60	Pre-boot	29	3.1	2.1	16	0.22	0.25	74
5-18-59	Boot	35	1.9	2.0	16	0.19	0.18	68
6-23-60	Boot	33	2.6	2.0	17	0.22	0.24	70
6-2-59	Early head	40	1.7	2.1	19	0.18	0.18	68
6-2-60	Late boot	34	2.2	2.3	20	0.21	0.28	73
6-16-59	Head	40	1.7	7.5	22	0.18	0.20	72
6-16-60	Head	43	2.2	2.7	24	0.18	0.28	65
7-1-59	Seed stage	51	1.4	2.9	22	0.14	0.18	53
8-5-60	Mature	65	0.7	3.0	27	0.22	0.26	48

posed before stem elongation, and extending to early August when grasses were mature and dry. Crude fiber values on these grasses are somewhat lower than generally reported; however, these data do compare with the lower range of crude fiber values reported by Miller (1958) for corresponding stages of plant growth. These low values can possibly be attributed to the precipitation pattern, which in most years hastens maturity, slowing chemical changes that would normally take place. These data are presented for 1959 and 1960 and show the difference in growth stage at corresponding dates as well as chemical values between years.

Table 2 shows the decline in nutritive content of the diet of

Table 2—Average concentration of certain chemical constituents in the diet of cattle on range forage during the grazing season*

Date	N	Cellulose	Phosphorus	Lignin†	Crude fiber
	%				
May 1	3.01	24	0.22	4.2	20
May 15	2.83	25	0.20	4.3	20
May 29	1.92	27	0.19	4.6	22
June 12	1.70	28	0.18	5.6	23
June 26	1.38	29	0.17	6.6	23
July 10	1.18	30	0.16	6.9	24
July 24	1.01	30	0.15	7.2	25
August 7	0.85	30	0.14	7.4	25
August 21	0.67	30	0.12	7.6	25
September 4	0.53	30	0.11	7.7	25
September 18	0.46	30	0.11	7.7	25

* The values reported are averages of 4 to 8 samples on each date during 1961 to 1964 inclusive. † Lignin values were determined by 72% H_2SO_4 method.

grazing cattle as the season progresses from late spring to late summer. These data are averaged from determinations on both native and introduced grasses under simulated grazing, and from the samples obtained by the rumen evacuation method with rumen-fistulated steers over several years. Digestibility was determined by the indicator method using chromium oxide with total collection. Digestibility was also determined on individual species by clipping the forage and feeding caged sheep. Table 3 shows the digestibility of the grazing ruminant diet at various times during the grazing season. The dates in the table are average dates of the span of the collection period for each digestion trial. Digestibility is closely associated with the chemical composition of the forage for the respective dates. *In vitro* cellulose digestibility was determined on the more important native grasses and crested wheatgrass and was reported by Wallace, Rumburg, and Raleigh (1961).

Table 3—Average digestibility of nitrogen, energy, cellulose, and dry matter of range forage during the grazing season*

Date	Nitrogen	Cellulose	Gross energy	Dry matter
	%			
May 29	65	70	63	62
June 12	64	68	63	62
June 26	63	60	62	59
July 10	58	56	58	57
July 24	44	54	57	52
August 7	36	58	51	49
August 21	28	52	48	48
September 4	26	52	46	48

* The values reported are averages obtained from digestion trials with 4 to 6 yearling steers or yearling sheep at the approximate forage harvest dates listed during the years 1961 to 1964 inclusive.

II. FORAGE EVALUATION: LIVESTOCK

Another criterion for forage evaluation is the extent to which forage nutrients meet the needs of different classes of livestock for various levels of production. After forage has been chemically evaluated, a measure of voluntary intake by different sizes and classes of livestock is needed to determine nutrient intake. Voluntary forage intake has been determined with yearling beef cattle on the Squaw Butte Station range at 2- to 4-week intervals during the summer grazing season. These studies employed the use of various techniques, namely, before and after clipping, chromium oxide with fecal N, and chromium oxide with total fecal collection; the last-named technique was most used. Intake studies with older or mature cattle have been limited; so some of the data presented on mature cattle are calculated values.

The digestible protein and energy intake of yearling cattle grazing native or introduced range grasses is illustrated in Fig. 1 and 2, respectively. These data were determined by measuring the intake of forage dry matter at various intervals during the grazing season and relating this to nutrient content and digestibility during these periods. Also included are the amounts of each of these nutrients needed for yearlings to maintain certain increments of production. These data

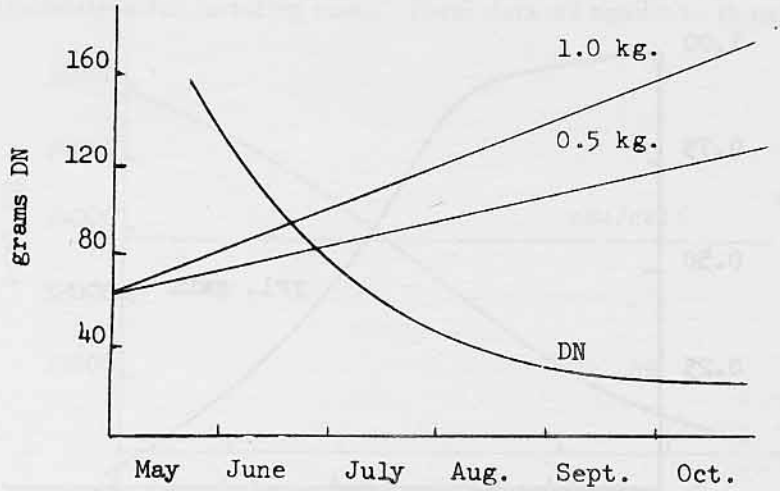

Fig. 1—Amount of digestible nitrogen required for maintenance plus 0.5 and 1.0 kg daily gain of 250-kg yearling steers and the amount they will get from range forage.

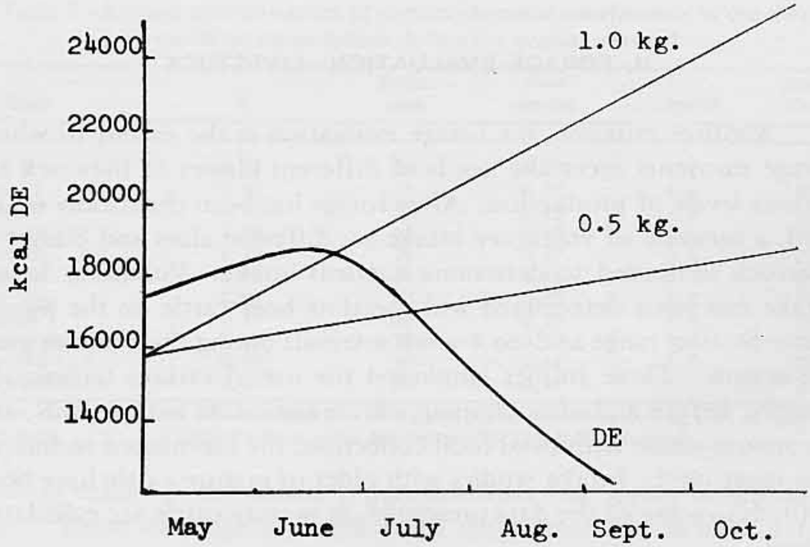

Fig. 2—Amount of digestible energy required for maintenance plus 0.5 and 1.0 kg daily gain of 250-kg yearling steers and the amount they will get from range forage.

indicate that protein becomes lacking about mid-June and energy in late June for yearling cattle expected to maintain a daily gain of 1 kg. Figure 3 shows the average daily gain of yearling steers, unsupplemented on range forage of adequate quantity, during the years 1960 to 1967, inclusive. Yearling steers will gain 0.9 kg or more per day

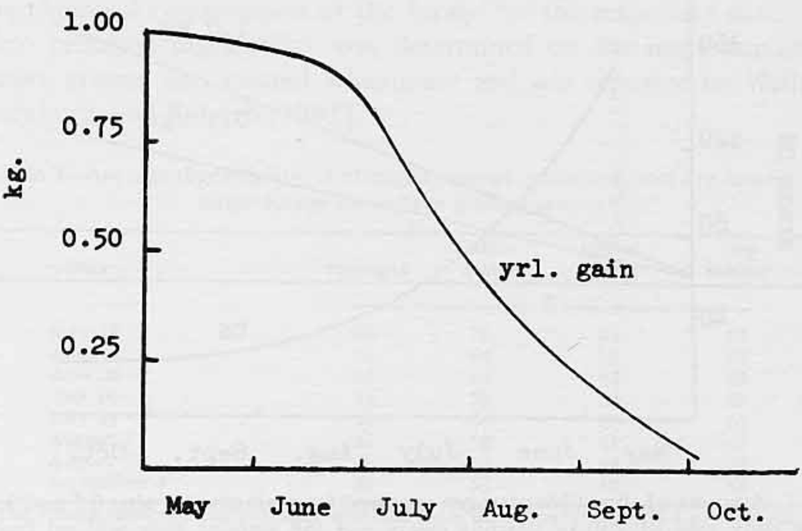

Fig. 3—Average daily gain of yearling steers during time on range.

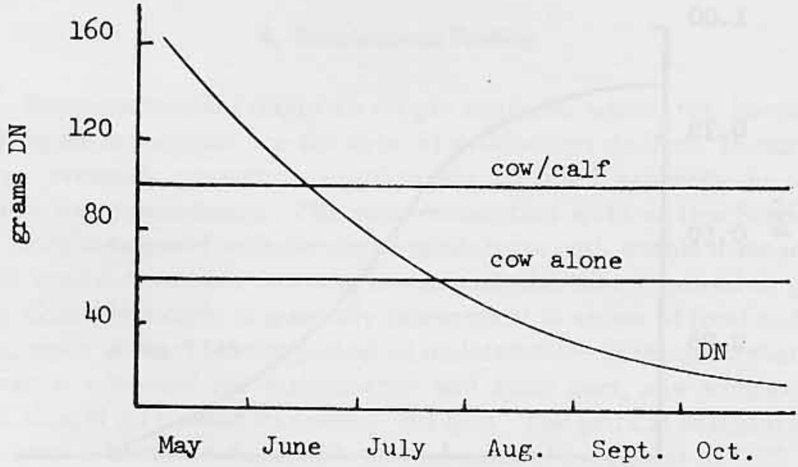

Fig. 4—Amount of digestible nitrogen required by cows with calves and dry cows and the amount they will get from the range forage.

during May and June, about 0.7 kg during July, less than 0.5 kg in August, and make little or no gain after September 1.

The digestible protein and energy intake of mature cows nursing calves and the amounts required for production are shown in Fig. 4 and 5, respectively. Some of the data used in calculating these figures are from actual intake studies and some were extrapolated from yearling data and from production data of the cows and calves. The production requirement is based on the National Research Council recommendation for lactating cows. These data are similar to those for

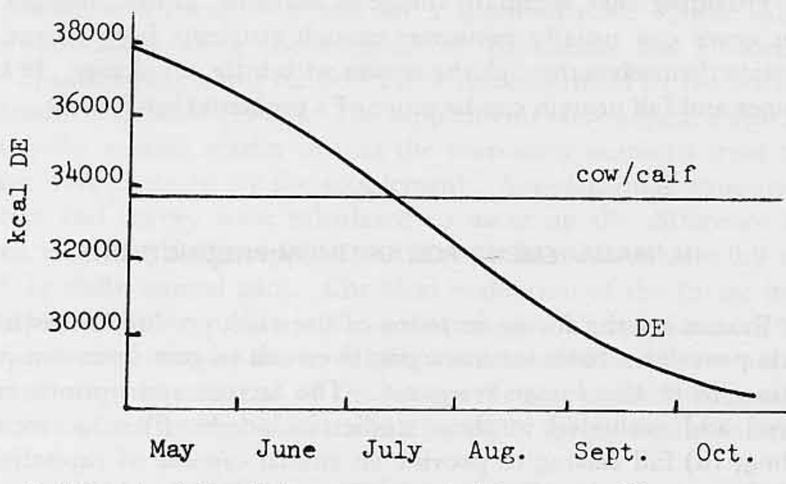

Fig. 5—Amount of digestible energy required by cows with values and the amount they will get from the range forage.

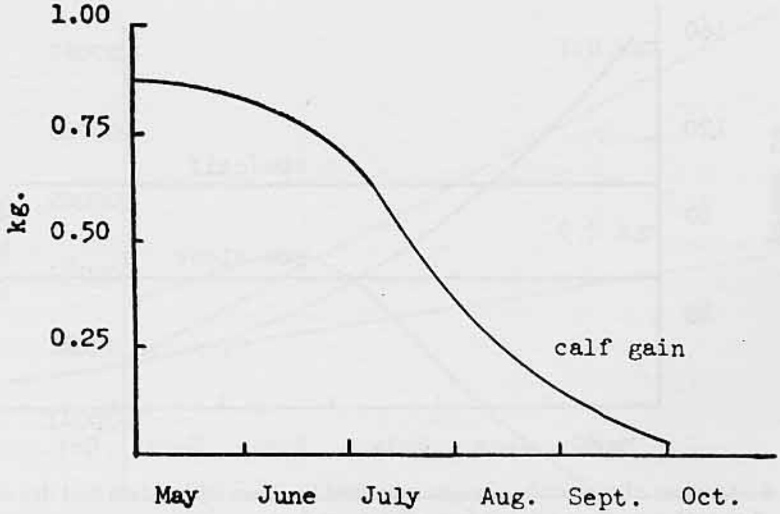

Fig. 6—Average daily gain of suckling calf during time on range.

yearlings, except that energy does not become limiting as early with mature animals as with the yearlings. This is probably due to the greater capacity of the rumen and consequent greater intake of the larger animal. Figure 6 shows the average daily gain of calves nursing these cows. Calves under this type of management follow a similar pattern to that of yearlings with average daily gains of about 0.8 kg per day during May and June, 0.6 kg during July, less than 0.4 kg during August, and little or no gain after the first of September.

Providing that adequate forage is available, either pregnant or open cows can usually consume enough nutrients from forage to maintain themselves through the season with little net change. In late summer and fall protein can be more of a problem than energy.

III. MANAGEMENT FOR OPTIMUM PRODUCTION

Evaluating the forage in terms of livestock production requirements provides a basis for managing livestock to gain optimum production from the forage resources. The factors and options considered and evaluated in these studies included: (i) supplemental feeding; (ii) fall calving to provide an animal capable of capitalizing on high-quality spring forage; and (iii) removal of saleable classes of livestock before economic production from range forage ceases.

A. Supplemental Feeding

Supplementation ought to supply nutrients when they become lacking or inadequate for the type of production desired. In many range livestock operations supplements are used primarily in the winter for maintenance. The supplementation work at this Station has been concerned with increased production with salable livestock. With regard to salable animals, minimizing the time required to get to a desirable weight is generally economical in terms of food nutrients, since it shortens the period of maintenance. It is logical that if forage is adequate for maintenance and some gain, any additional feed should go toward increasing this gain. The work at this Station has been primarily concerned with maintaining daily gains of 0.75 kg or more on yearling cattle.

The work reported here was designed to determine the kinds and amounts of supplementation required by yearling cattle on range forage to make a specified gain throughout the grazing season. Some of this work has been reported by Raleigh and Wallace (1963, 1964), while other studies are unpublished. Data appearing in the charts and tables are averages or compilations of all studies completed.

Figures 1 to 6, which have been previously discussed, provide the basis for selecting levels of supplements. These figures show the amount of protein and energy yearling animals should get from range forage during various intervals of the grazing season when adequate forage dry matter is available. They also show the calculated amount of protein and energy required for a specified gain. These values were calculated using the formula of Winchester and Hendricks (1953) and requirements for beef cattle recommended by the National Research Council (1963). The supplements were adjusted upward during the grazing season so that the decreasing nutrients from the forage were replaced by the supplements. Supplemental amounts of protein and energy were calculated to make up the difference between what the forage supplied and that necessary to achieve 0.9 and 1.15 kg daily animal gain. Chemical evaluation of the forage indicated high nutritive quality in the early part of the grazing season, but studies showed that dry matter intake was restricted during the period of high moisture content of the forage. It was assumed that small amounts of an energy supplement in early spring would increase gains.

The first series of studies combined a 2 X 2 factorial design, with two protein and two energy levels and a nonsupplemental con-

Table 4—Average daily gain of animals on various supplements

Supplement*		Period		Average
Nitrogen	Energy	5/6-7/3	7/3-8/30	
		kg		kg
0	0	0.77	0.41	0.59
Low	Low	0.95	0.91	0.93
Low	High	0.91	0.95	0.93
High	Low	1.00	0.95	0.98
High	High	1.00	0.95	0.98

* Low and high nitrogen and energy levels were calculated to provide for 0.9 and 1.15 kg gain per day, respectively.

trol group. Protein and energy were each supplemented to provide for 0.9- and 1.15-kg daily gain. Results of these studies are summarized in Table 4. Other data from these studies indicated that it was impractical to supplement at these levels beyond the middle of August or to maintain gains of much over 0.9 kg per day. Intake studies (Raleigh and Wallace, 1963; Harris et al., 1967) indicated that the higher level of supplement inhibited forage intake in the later period. These studies showed an interaction between levels of supplementation and forage intake associated with forage maturity; forage intake was higher with the upper level of supplementation than with the lower level and the controls in mid-June, and the reverse occurred in mid-August.

Table 5—Daily supplemental nutrient intake of yearling steers within each treatment group*

Period	Supplemental nutrient†	
	Nitrogen	Digestible energy
	g	kcal
5/10 - 5/21	7.8	1,404
5/22 - 5/29	4.9	936
5/30 - 6/5	3.8	702
6/6 - 6/12	3.2	645
6/13 - 6/19	14.4	840
6/20 - 6/26	17.2	1,120
6/27 - 7/3	23.2	1,420
7/4 - 7/10	28.5	1,800
7/11 - 7/17	34.0	2,200
7/18 - 7/24	38.4	2,460
7/25 - 8/3	44.2	3,550
8/4 - 8/12	47.3	4,000

* Three supplemental treatments were used: (1) control, no supplement; (2) half season, supplements as shown beginning on June 13; and (3) all season, supplements as shown for entire period. † Cottonseed meal and barley were used as supplemental sources of N and DE. While extra N was not considered necessary between 5/10 and 6/12, the barley provided small amounts as indicated.

Table 6—Average daily gain of animals on supplemental treatment*

Period	Supplemental treatment		
	None	Half season	All season
	kg		
5/10 - 6/11	1.04	1.05	1.24
6/12 - 7/12	0.88	0.92	1.00
7/13 - 8/12	0.47	0.94	0.87
Average	0.80	0.97	1.04

* See table 5 for amounts of supplement fed.

The supplement levels for treatment groups are shown in Table 5. In these studies one group of animals received no supplement, the second group was supplemented as in the previous study starting in mid-June with a supplemental level calculated to provide for a 0.9 kg gain/day, and the third group was supplemented the same as the second except that additional energy was provided commencing with the start of the trial when moisture content of the forage was high. Daily gain for respective treatments is shown in Table 6. There was a significant increase in daily gain from the early supplementation, with both supplemented treatments resulting in significant gains over the control group.

These data indicate that gains can be increased by supplementing yearlings when forage quality is high. The study suggests several alternatives for management. If yearlings are large and range forage is limiting, supplementing during May and June will give a good return on the supplement and permit marketing the first of July. This would save the additional feed for other cattle. On the other hand, if cattle are lighter when turned onto the range, supplementation to about mid-August will give a good return.

The feasibility of producing slaughter-grade livestock by range supplementing was investigated. Results of this study have been reported by Raleigh, Wallace, and Turner (1967). In these studies yearling steers were supplemented on range over a 6-month grazing period (May 1 to November 1). Supplemental levels were based on the quality of the forage during the grazing season and the amounts of nutrient required for the animal to gain 1.15 kg daily. Supplement levels in these studies were rapidly increased during August and early September so that by September 15 the yearlings were receiving 1.75% of their body weight as supplements. As stated earlier, forage intake declines about mid-August as supplement levels are increased. This level was continued to early November, at which time the cattle were slaughtered. In the study cited above and in further studies at this Station, a total of 50 animals have been slaughtered with 6 carcasses grading choice; 41, good; and 3, stardard. Further studies are needed, but results indicate this to be a feasible means of increasing livestock production from the forage resource.

B. Fall Calving

The majority of calves are dropped in March and April in many of the range land areas. This means that a calf is going on range at a time of high forage quality, when it is not big enough to make full use of either the increased milk production from the mother, or the high-quality forage. By the time the calf is large enough to take advantage of the feed, the quality of the forage has declined greatly, resulting in a decrease in milk production and consequent decline in daily gain of the calf (Fig. 6).

Fall calving, although it increases the cost of wintering the cow, should provide a bigger calf to go on range and make better use of the high-quality feed through May, June, and July. A fall calving program with calves dropped in October and November was initiated at the Station to study the advantages and disadvantages of fall calving and the nutritional and management requirements associated with fall calving. In the early stage of the study, fall calf weaning weights have exceeded spring calf weights by 70 kg, while cost for wintering the fall calving cow over the spring calving cow has increased about $10. A program of this nature may not be applicable to all livestock operators, but it does provide an alternative opportunity in managing livestock to give a greater return from our range forage resource.

C. Removable of Saleable Cattle

Traditionally, range livestock operators have turned animals onto the range in spring and removed them in the fall with little regard for animal performance. Data presented in Fig. 1 to 6 provide a basis for changing this type of management. For those livestock operators who choose not to adopt some of the supplementation or management practices described previously these data support the removal of saleable classes of livestock from the range forage once animal gains cease. Yearling cattle make almost no gain after September 1, so they should be removed from this forage prior to this time. Suckling calves follow this same pattern, so early weaning should be practiced. This will leave the additional feed for maintenance of the breeding herd and can actually provide for an increase in total cow units as well as permit cows to come into the winter in better condition. This Station has shown that early weaning of calves is economical, with the advantages of early weaning extending throughout the winter period (Wallace and Raleigh, 1961).

IV. SUMMARY

Forage resources were inventoried, both quantitatively and qualitatively, to establish a base for developing a range livestock and forage management program. Range forage was evaluated both chemically and in terms of animal production throughout the grazing season. Methods of managing livestock, with respect to seasonal change in forage quality, for optimum production were studied.

Nitrogen and digestible energy of range forages decrease from a level capable of producing gains in excess of 1.0 kg per day on yearling cattle in May, to maintenance level by October.

Yearling steers were supplemented at relatively low levels to maintain gains up to 1.0 kg per day until mid-August. The supplements were calculated to supply the difference in nutrients between that required by the animals and that which the forage supplied. This meant starting at 0 and increasing supplements as forage nutrients decreased.

Additional energy was provided early in the season when moisture content of the forage was greater than 60%. Animals receiving energy supplements during the period from May 10 to June 11 made daily gains 0.1 kg above those on the same forage with no supplement. This supplement amounted to an average of 1000 kcal of digestible energy per day or about 0.3 kg of barley per head daily.

Yearling steers were brought to a slaughter grade by supplementing on range from early May to November. Supplemental levels were based on the quality of the forage throughout the grazing season and the amount of nutrients required for a gain of 1.15 kg per head daily. Supplemental feed was increased to feedlot proportions during the last 45 days on range. The majority of the carcasses graded high good.

Fall calving to provide larger and more mature calves that could make better use of the short period of high-quality early season range forage was studied. Fall calves were weaned at a weight 70 kg greater than the spring dropped calves, at an increased winter feed cost of about $10.

Results of these studies indicate that it is feasible to manipulate livestock management, based on the knowledge of forage quality relative to livestock performance, for increased livestock production.

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