Drought Effects on Diet and Weight Gains of Yearling Heifers in Northeastern Oregon

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Abstract

Daily weight gains and diets of cattle were evaluated during a year with average precipitation and in a drought year on mountain range in northeastern Oregon. Forage intake was evaluated only in the drought year. Esophageally fistulated heifers were used to sample diet quality and botanical composition. Botanical composition of cattle diets was different ($P<.05$) in the late spring and early summer between years. When green grass and forbs were not available, browse was heavily utilized. Livestock weight gains and forage intake in the latter part of the grazing season were reduced ($P<.05$) during the drought year. This is attributed to depletion of browse, primarily common snowberry *(Symphoricarpos albus)*. Diet crude protein and neutral detergent fiber concentrations were significantly ($P<.05$) correlated with average daily gains. When ruminants are consuming diets with more than one forage class, neutral detergent fiber and composition and yield of volatile fatty acids may more accurately evaluate the energy status of the diet than digestibility. Supplementation of crude protein could potentially improve average daily gains during drought years if browse was unavailable. Ranges with a high component of forbs and shrubs will ameliorate the negative effects of drought on average daily gains.

Drought affects herbivores grazing most of the world's rangelands. Considerable information is available concerning the influence of drought on range vegetation, but the influence on herbivore performance and diet has received little study. Available information on range cattle in the United States was summarized by Wallace and Foster (1975). On forested range in eastern Oregon, Vavra and Phillips (1980) reported that drought affected in vitro dry matter digestibility of cattle diets more than crude protein, lignin, or acid detergent fiber concentrations. Cows and calves were lighter at the end of the grazing season during the drought year than in the other 2 years of study. The present study was conducted to evaluate the effects of drought on diet botanical composition, diet quality, and weight gains of yearling heifers. Our data should provide a better understanding of the effects of drought on other ruminants.

Study Area and Methods

The study area was located on the 11,735-ha Starkey Experimental Range and Forest in the Blue Mountains of northeastern Oregon, U.S.A. Broad rolling uplands separated by deep canyon drainages characterize the Starkey Range. Approximately 70% of the area is forested and 30% is grassland. Elevations range from 1,070 to 1525 m. A thorough description of the study area is given by Skovlin et al. (1976). The average annual precipitation is approximately 59 cm and comes as snow and rainfall in the winter and spring. In approximately 1 year out of 2, there is sufficient rainfall in the summer to result in early fall regrowth on the grassland areas. Growing season precipitation on the experimental area in 1976 and 1977 is given in Table 1. A complete description of the vegetation on the experimental area is given by Ganskopp (1978). The principal herbage species on the pasture were Idaho fescue *(Festuca idahoensis)*, bluebunch wheatgrass *(Agropyron spicatum)*, Sandberg bluegrass *(Poa sandbergii)*, elk sedge *(Carex geyeri)* and common snowberry *(Symphoricarpos albus)*. Relative percent cover of important forage species on the pasture is presented in Table 1. Approximately one half the pasture was forest and one half was grassy openings. Ponderosa pine *(Pinus ponderosa)* dominated the overstory and common snowberry dominated the understory of forested areas.

In both years of study, grazing was initiated on June 20 and terminated October 10. The pasture was stocked at a moderate rate (3.2 ha/AUM) with 7 head of Hereford/Angus crossbred yearling heifers during both years of study. In addition 3 Hereford heifers equipped with esophageal fistulas were kept in the pasture. Weight gains of livestock were evaluated during 4 different periods of each year based on plant phenological development using a portable scale and corral. The time intervals for the four periods were June 20 to July 18 (late spring), July 19 to August 15 (early summer), August 16 to September 12 (late summer), and September 13 to October 11 (fall). Esophageally fistulated animals were not included in livestock performance data. Fistula collections were made twice every other week so that 12 samples were collected per period. The same fistulated cattle were used each year. Walker et al. (1981) reported that breed and age had small effect on cattle diet botanical composition. Therefore the fact that the fistulated cattle were of a different breed and a year older than the cattle used for weight gain evaluation in 1977 was probably of minor importance.

A total of 12 diet samples (3 heifers × 4 collections) were evaluated for each period. Crude protein was determined by

Table 1. The precipitation (cm) at the Starkey Experimental Range.

Month	1975–1976		1976–1977		25 year $\bar{X}$
September	1975	0.0	1976	3.7	2.7
October	1975	3.0	1976	2.7	4.5
November	1975	3.2	1976	4.1	5.7
December	1975	2.9	1976	0.0	6.7
January	1976	6.9	1977	1.0	6.5
February	1976	2.3	1977	2.4	4.3
March	1977	2.5	1977	2.5	4.6
April	1976	5.1	1977	2.7	4.4
May	1976	6.4	1977	4.8	5.4
June	1976	4.7	1977	1.3	4.7
July	1976	0.1	1977	0.1	1.6
August	1976	6.9	1977	7.4	2.0
Annual total		44.0		32.6	53.1
Percent of 25-year average		83		62	

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AOAC (1980) methods. The in vitro digestion technique of Tilley and Terry (1963) as modified by Vavra et al. (1973) was used to determine organic matter digestibility. Neutral detergent fiber was determined by the technique of Van Soest (1963). Permanganate lignin and acid detergent fiber were determined with the technique of Van Soest and Wine (1968). All data were converted to an organic matter basis.

In 1977 the 3 fistulated heifers were used to make total 24-hour fecal collections in the middle of each period. The device described by Kartcher and Rittenhouse (1979) was used to prevent urine contamination of feces when fecal collections were made. Organic matter intake was calculated from total 24-hour fecal output by using the equation of Van Dyne (1968):

$$\text{Organic matter intake} = \frac{(100) \times (\text{total fecal organic matter output})}{100 - \%\ \text{IVOMD}}$$

Forage intake was expressed as a percentage of body weight (BW) as discussed by Cordova et al. (1978).

Diet botanical composition of fistula samples was determined by the technique of Sparks and Malechek (1968). A total of 20 microscope fields were read on each of 3 slides for a total of 60 fields per sample. Frequency was converted to density using the table of Fracker and Brischle (1944). The relative percent density was assumed to equal the relative percent by weight composition (Sparks and Malechek 1968).

Differences in diet quality, diet botanical composition, and daily weight gains between years for each period were analyzed using a completely randomized one way analysis of variance model. Kulczynski's formula discussed by Oosting (1956) was used to compare diet similarity between years for each period. Correlation analysis was used to evaluate the degree of association between weight gains and diet nutritive value.

Results and Discussion

Idaho fescue was the most important species in diets when samples were pooled across years and periods (Table 2). Other important species in the diet included bluebunch wheatgrass, common snowberry, Sandberg bluegrass, Kentucky bluegrass *(Poa pratensis)*, and elk sedge.

Similarity values between years for the late spring, early summer, late summer, and fall periods were 38%, 39%, 59%, and 81%, respectively. This shows that cattle diets on the same range can vary drastically between years.

During 1976 grasses in cattle diets showed a steady increase with seasonal advance (Table 2). In 1977 grasses comprised the bulk of the diet in all periods except early summer when cattle made heavy use of shrubs. Forb use showed a steady decline with seasonal advance in both years. Pickford and Reid (1948) and Holechek et

Table 2. Relative percent cover of the primary forage species and their percent by weight contribution to cattle diets.

Species	Percent cover	Percent in diet[2]
Grasses		
Bluebunch wheatgrass *(Agropyron spicatum)*	7	11
Idaho fescue *(Festuca idahoensis)*	15	22
Elk sedge *(Carex geyeri)*	6	5
One-spike danthonia *(Danthonia unispicata)*	2	T
Western fescue *(Festuca occidentalis)*	2	T
Kentucky bluegrass *(Poa pratensis)*	4	5
Sandberg bluegrass *(Poa sandbergii)*	16	6
Cheatgrass *(Bromus tectorum)*	7	T
Miscellaneous grasses	T	14
Total grasses	59	65
Forbs		
Western yarrow *(Achillea millefolium)*	2	4
Heartleaf arnica *(Arnica cordifolia)*	1	T
Clover (*Trifolium* spp.)	1	2
Lupine (*Lupinus* spp.)	3	T
Wyeth eriogonum *(Eriogonum heracleoides)*	2	T
Cluster tarweed *(Madia glomerata)*	2	0
Miscellaneous forbs	7	12
Total forbs	18	19
Shrubs		
Common snowberry *(Symphoricarpos albus)*	9	9
Ninebark *(Physocarpus malvaceus)*	6	2
Spiraea *(Spiraea betulifolia)*	1	T
Twinflower *(Linnaea borealis)*	2	T
Miscellaneous shrubs	5	4
Total shrubs	23	16

[1]Cover data from Ganskopp (1978).
[2]Diet samples were pooled across years and periods.
T=trace.

Table 3. The percent by weight of important species found in cattle diets in 1976 and 1977.

Item[1]	Late spring 1976	Late spring 1977	Early summer 1976	Early summer 1977	Late summer 1976	Late summer 1977	Fall 1976	Fall 1977
Grasses								
Idaho fescue	15	17	15[a]	9[b]	41[a]	22[b]	29	29
Bluebunch wheatgrass	2[a]	9[b]	14[a]	3[b]	11	16	15	19
Sandberg bluegrass	10[a]	5[b]	3	4	4	4	8	7
Kentucky bluegrass	6	9	9[a]	5	4	1	6	T
Elk sedge	T	6	1	4	1[b]	14[a]	4	5
Miscellaneous grasses	9[a]	26[b]	11	7	17	18	23	25
Total grasses	42[a]	72[b]	53[a]	32[b]	78[a]	75[b]	85	85
Forbs								
Clover	10[a]	2[b]	1	2	—	T	1	1
Western yarrow	8[a]	2[b]	11[a]	4[b]	6[a]	1[b]	1	1
Miscellaneous forbs	34[a]	18[b]	20[a]	9[b]	4	8	3	4
Total forbs	52[a]	22[b]	32[a]	15[b]	10	10	5	6
Shrubs								
Common snowberry	3	5	6[a]	30[b]	8	9	6	4
Ninebark	—	—	2	4	—	5	T	T
Miscellaneous shrubs	3	1	7[a]	19[b]	4	1	3	5
Total shrubs	6	6	15[a]	53[b]	12	15	10	9

Means with different superscripts within periods differ significantly ($P < .05$).
T=trace amount in diet.

Table 4. Diet chemical composition, diet digestibility, forage intake, and average daily gains (kg/day) for cattle.

Item[1]	Late spring 1976	Late spring 1977	Early summer 1976	Early summer 1977	Late summer 1976	Late summer 1977	Fall 1976	Fall 1977
Average daily gain (kg)	0.78	0.76	0.53	0.70	0.63[a]	0.05[b]	0.66[a]	0.31[b]
Crude protein (%)[2]	14.7	13.8	11.3	10.9	13.7[a]	8.3[b]	11.0[a]	8.4[b]
Cell solubles %[2]	38.8[a]	27.2[b]	30.3[a]	35.4[b]	31.4[a]	22.3[b]	25.2[a]	18.5[a]
Neutral detergent fiber (%)[2]	61.2[a]	72.8[b]	69.7[a]	64.6[b]	68.6[a]	77.7[b]	74.8[a]	81.5[b]
Acid detergent fiber (%)[2]	51.1[a]	65.1[b]	51.4[a]	56.4[b]	59.6[a]	64.6[b]	60.6[a]	67.3[b]
Lignin (%)[2]	17.0[a]	13.4[b]	17.3[a]	21.2[b]	15.6[a]	18.3[b]	14.3[a]	16.4[b]
In vitro digestibility, 48 hour (%)[2]	69.4	69.9	54.7[a]	48.9[b]	56.8[a]	51.9[b]	55.2	53.6
Forage intake[3]	—	2.20	—	2.17	—	1.97	—	2.14
Crude protein intake[3]	—	.30	—	.24	—	.16	—	.18
Cell soluble intake[3]	—	.60	—	.77	—	.44	—	.40
Digestible organic matter intake[3]	—	1.54	—	1.06	—	1.02	—	1.15

[1]Means within periods with different superscripts are different ($P<.05$).
[2]Data are on organic matter basis.
[3]Organic matter as a percent of body weight.

al. (1982a,b) reported similar trends in forb consumption at the Starkey Range.

Forbs in cattle diets in the late spring and early summer were lower ($P<.05$) during the drought year in 1977 than in 1976 probably due to reduced palatability and availability. Most forb species had reached maturity and dried by early July while in 1976 they remained green until the early part of August. Vavra (1972) reported reduced forb consumption for cattle in a dry year because forbs matured earlier than in wet years and fewer kg per ha were produced.

A major change in shrub use occurred in the early summer of 1977. Leaves on common snowberry remained green after the grasses matured. By the middle of the 1977 grazing season, common snowberry showed very heavy use. This explains the sharp dietary decline in shrubs in the late summer. Other researchers have reported browse was heavily utilized by cattle when green grass was unavailable (Conner et al. 1963; Cook and Harris 1968a; Lespearance et al. 1970; Rosiere et al. 1975a,b; Holechek et al. 1982a,b).

Diet Quality

During both years of study, diet crude protein values showed a steady decline as the grazing season advanced (Table 4). Crude protein values were higher ($P<.05$) during the second half of the grazing season in 1976 than in 1977.

Protein requirements for growing yearling heifers, as outlined by the NRC (1976), indicate that 320 kg heifers require 9.7% crude protein on an organic matter basis for a 0.8 kg gain. Crude protein concentrations in diet samples were below this requirement in the latter half of the grazing season in 1977.

During the early summer of 1977, browse (primarily common snowberry) apparently enabled cattle to maintain an adequate crude protein concentration in their diet. Cook and Harris (1968a), Dietz (1972), Cook (1972), Huston et al. (1981), and others have shown that browse retains more crude protein than mature grasses or forbs. Composite samples of forage species collected in 1976 confirm the higher crude protein content of shrubs compared to grasses on the study pasture (Table 5).

Cell solubles (neutral detergent fiber % −100) were higher and total cell wall constituents (neutral detergent fiber) were lower ($P<.05$) in 1976 than 1977 except for the early summer period. Forbs and browse comprised 68% of the diet in this period in 1977 compared to 47% in 1976. Leaves of forbs and shrubs have higher cell soluble concentrations and less total fiber than grass leaves and stems at comparable stages of maturity (Short et al. 1974, Huston et al. 1981, and Table 5).

In vitro organic matter digestibility (IVOMD) and lignin values showed no trend with seasonal advance in either year of study. During the early and late summer IVOMD values were higher ($P<.05$) in 1976 than in 1977.

Forage Intake

Because forage intake data were not collected in 1976, the influence of drought on forage intake cannot be fully evaluated. However, the forage intake data for 1977 show some interesting trends. Intake was much lower ($P<.05$) in the late summer than in the early summer. The reverse was true for diet in vitro digestibility. In the early summer the diet was dominated by shrubs while grasses dominated the diet in late summer. Considerable research shows that leaves of forbs and shrubs have faster digestion rates (Short et al. 1974, Smith et al. 1972, Mertens 1973, Woffard and Holechek 1982) and passage rates (Ingalls et al. 1966, Mertens 1973, Milchunas et al. 1978) than grass leaves and stems in the ruminant digestive tract. Ingalls et al. (1966) found the average rumen retention time in sheep of 2 grasses was .89 day compared with .65 day for two legumes. Arthun (1981) reported that organic matter intake by cattle was 33% higher for alfalfa *(Medicago sativa)* than for bermudagrass *(Cynodon dactylon)* although the 48-hour in vitro digestibility of the two forages was the same. Thornton and Minson (1973), working with sheep, found that voluntary intake was 14% higher for legumes than grasses, although organic matter digestibility was 63% for the grasses compared with 53% for the legumes. White-tailed deer intake

Table 5. Nutritive quality of composite samples of the primary forage species from the Starkey Range collected during the late spring and fall during 1976.

Forage class[1,2]	Time collected	IVOMD[3]	Crude protein %	Cell soluble %	Neutral detergent fiber %	Acid detergent fiber %	Permanganate lignin %
Grasses	Late spring	56	12	32	68	56	7
	Fall	47	8	24	76	63	10
Forbs	Late spring	60	15	57	43	32	9
	Fall	44	9	36	64	57	12
Shrubs	Late spring	48	13	54	46	35	13
	Fall	42	11	47	53	42	16

[1]Data are on organic matter basis.
[2]Plant materials were primarily leaves.
[3]In vitro organic matter digestibility.

averaged 15% higher when they were fed browse diets averaging 50% in vivo digestibility than when fed brome hay (*Bromus* sp.) averaging 72% in vivo digestibility (Robbins et al. 1975). In a separate study on the Starkey range, Holechek and Vavra (1982) found forage intake by cattle was higher when cattle consumed forb and browse dominated diets than when diets were dominated by grasses.

Data in Table 5 show a lower cell wall and a higher lignin content for forbs and shrubs compared to grasses. Forages with a low cell wall content typically have more rapid rates of rumen fermentation (Smith et al. 1972, Short et al. 1974) and faster passage rates (Ingalls et al. 1966, Mertens 1973, Osbourne et al. 1974, Milchunas et al. 1978) than those with a high cell wall content. Leaves of forbs and shrubs typically have lower cell wall contents than grass leaves and stems at comparable stages of maturity (Short et al. 1974, Huston et al. 1981). Van Soest (1982) provides a detailed discussion of why cell wall concentrations are critical in forage intake regulation of ruminants.

Forages with high lignin contents (primarily forbs and shrubs) tend to have low cell wall contents and higher intakes than those of low lignin contents (primarily grasses) (Van Soest 1965, 1966). Within forage classes lignin is negatively related to intake but little relationship exists between intake and lignin when forage classes are mixed (Van Soest 1965, Mertens 1973). The higher lignin content of forb and shrub leaves and stems compared to grass leaves and stems may increase passage rate by making these parts more brittle causing finer fragmentation (Milchunas et al. 1978). Finer particles pass more quickly out of the reticulo-rumen compared to larger ones (Van Soest 1966, Mertens 1973, Milchunas et al. 1978). There is also evidence that the short, broad, and more cubical shape of forb and shrub fragments permits quicker passage out of the reticulo-rumen than the long, thin, fiber like particles of grasses (Troelson and Campling 1968, Mertens 1973).

Protein deficiencies in the diet can substantially reduce voluntary intake by ruminant animals (Milford and Minson 1964, Cook and Harris 1968b). Research by Milford and Minson (1964) indicates forage intake by ruminants is not influenced by diet crude protein concentration unless it falls below 7%. Diet crude protein concentrations in our study never dropped below 8%.

Cattle Weight Gains

Cattle weight gains were reduced ($P<.05$) during the latter half of the grazing season in 1977 compared to 1976 (Table 4). The change from shrubs to grasses in the late summer of 1977 appears to account for the reduction in cattle performance. The influence of forage class on intake has been previously discussed. Intakes of crude protein and cell solubles were both substantially lower ($P<.05$) in the first half compared to the second half of the grazing season in !977 (Table 4).

Weight gains improved in the fall of 1977 compared to the late summer. This is attributed to regrowth that resulted from the rains in August (Table 1).

Simple correlation coefficients were used to evaluate the relationships between diet quality characteristics and average daily gains. Correlation coefficients for crude protein, neutral detergent fiber, acid detergent fiber, lignin and IVOMD with average daily gains (n = 8) were +.84, -.76, -.64, -.20, and +.60, respectively. Crude protein and neutral detergent fiber concentrations explained a substantial amount of the variation in average daily gains and were the only significant ($P<.05$) correlations.

Our study and that of Vangilder et al. (1982) suggest that in vitro digestibility is inferior to neutral detergent fiber analysis for evaluating the energy status of ruminant diets containing mixed forage classes. We have previously discussed other literature showing that total cell wall content (neutral detergent fiber) rather than digestibility is the primary factor determining forage intake when the ruminant diet contains mixed forage classes. Cell solubles are used more efficiently by ruminants than cell wall constituents (Van Soest 1982). Cell soluble concentrations have considerable effect on rate of digestion but not on extent of digestion (Smith et al. 1972, Mertens 1973, Short et al. 1974). Leaves of forbs and shrubs are higher in rapidly fermented cell solubles (Short et al. 1974, Huston et al. 1981) and have quicker passage rates than grasses at comparable stages of phenology (Mertens 1973, Milchunas et al. 1978). Production of large amounts of volatile fatty acids containing a high proportion propionate acid results from fermentation of forages high in cell solubles (Short 1971, Hoppe 1977). In contrast forages high in cell wall constituents (neutral detergent fiber) result in production of primarily acetic acid. Propionic acid is more efficiently used as an energy source by the ruminant than acetic acid because it can be converted directly to carbohydrate with minimum loss of potential energy in the form of methane (Hungate 1975). Energy metabolism in the ruminant is closely associated with volatile fatty acid production because their absorption from the rumen provides the host with about 70% of its energy requirement (Mitchell 1962). Two studies have shown an inverse relationship between sheep weight gains and the relative proportion of acetate in the rumen (Milford and Minson 1966, Johns et al. 1963). Molar concentrations of acetate and propionate accounted for 48% of the variation in lamb gains on pasture (Grimes et al. 1967). Acetate production is negatively and propionate production is positively related to cell soluble concentrations in the rumen Tilley et al. 1960. Milford and Minson 1966). Digestibility appears to be poorly related to volatile fatty acid concentrations in the rumen (Topps and Elliot 1964, Milford and Minson 1966). The previous discussion indicates digestiblity evaluation is inferior to neutral detergent fiber analysis as an indicator energy intake and energy efficiency at the cellular level of ruminants. Yield and concentration of volatile fatty acid in the diet would appear to give better appraisal of the energy status of the range ruminant's diet than neutral fiber concentration. Unfortunately this type of information is almost totally lacking for range ruminant diets and range forages although it is desperately needed. We believe it should receive considerable emphasis in future studies concerning energy metabolism of range ruminants.

Conclusions

Diets of cattle on rangeland in the Blue Mountains varied widely between and within years in both nutritive value and species composition. Cattle changed their diets with seasonal advance to make use of the best forage available. Common snowberry was heavily used during the drought until it was no longer available; cattle then changed to grasses. Forbs received heaviest use during the early part of the grazing season when they were available and actively growing.

Our data show cattle are opportunistic foragers and their diets can show great variation between years on the same range. Moderate cattle grazing on the range studied during a drought year could negatively affect wildlife such as mule deer that must select forages with rapid rates of digestion and quick passage rates through the digestive tract.

From the standpoint of livestock production, it appears ranges supporting a high component of palatable forbs and shrubs will improve weight gains during drought years compared to grassland ranges. This is because of the higher forage intake rates, higher crude protein concentrations, and lower fiber concentrations associated with the leafy material of forbs and shrubs compared to grasses. Crude protein supplementation could potentially improve weight gains during drought years after the browse (common snowberry) has been depleted.

Concentrations of crude protein and total fiber (neutral detergent fiber) were closely associated with average daily gain. However this relationship did not hold for diet IVOMD. Crude protein and neutral detergent fiber appear to be superior to acid detergent fiber, lignin and in vitro digestibility for quality evaluation of range ruminant diets containing a high component of forbs and shrubs. Digestibility is a poor indicator of efficiency of forage use by ruminants at the cellular level when the diet contains more than one forage class. Yield and concentration of volatile fatty acids in range ruminant diets and range forages may provide valuable information on energy metabolism by range ruminants although present research is very limited.

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