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209

FORAGE INTAKE AND PERFORMANCE OF RANGE COWS AS AFFECTED BY DELAYED WINTER SUPPLEMENTAL FEEDING AND MINERAL SUPPLEMENTATION

by

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TABLE OF CONTENTS

LIST OF TABLES

GENERAL INTRODUCTION

Nearly all cow herds depend entirely on grazed forage at least during the summer. Many herds in the Flint Hills of Kansas are maintained on native pasture year-round. An understanding of grazing cattle nutrition is incomplete without information on forage consumption. Since determining forage intake of grazing animals is expensive and very time consuming, information is limited. It cannot be assumed that research conducted with cattle grazing other types of pasture applies directly to the Flint Hills area. This research was undertaken to determine the levels of forage consumed and study some of the factors affecting forage consumption by cows grazing native Flint Hills pasture.

LITERATURE REVIEW

Control of feed intake

Ruminants will adjust voluntary feed intake in relation to physiological demand for energy if fill does not limit consumption (Montgomery and Baumgardt, 1965). Volatile fatty acids are the primary end products of digestion utilized for energy in ruminants. Many researchers have shown that injection of volatile fatty acids into the blood stream or reticulo-rumen will reduce feed intake (Manning et al., 1959; Rook et al., 1960 Baumgardt et al., 1964; Dowden and Jacobsen, 1960). Chemoreceptors that monitor volatile fatty acids can explain short term regulation of feed intake of ruminants on highly digestible diets, but physical restrictions of the gastrointestinal tract plays a more important role with most forage diets.

Campling and Balch (1961) found that removing dry matter from the reticulo-rumen increased intake and adding dry matter or water filled bladders decreased consumption of forages. Freer and Campling (1963) fed cows forages differing in organic matter digestibility by 16% and observed that consumption ceased when a similar amount of digesta was in the reticulo-rumen. This suggests that dry matter intake of forages is limited by physical restrictions of space in the gastro-intestinal tract (Blaxter et al., 1961). As digestibility of forages increases, voluntary intake increases (Blaxter and Wilson, 1962; Campling et al., 1961; Crampton, 1957). As rate of fiber digestion decreases intake of forage decreases (Gill et al., 1969; Fontenot and Blaser, 1965; Crampton, 1957; Campling et al., 1961.) Others have shown that an increase in rate of passage allows an increase in intake (Campling et al., 1962; Blaxter et al., 1961; Dinus and Baumgardt, 1970). Van Soest (1965) summarizes these ideas by saying:

> Relief from increased volume is afforded either by an increase in rate of digestion or by a faster rate of passage.

<u>Forage intake in relation to body weight and milk production</u>

Conrad <u>et al</u>. (1964) analyzed 114 digestion trials with dairy cows. When the dry matter digestibility of a high roughage ration was between 52 and 66%, body weight, rate of passage and dry matter digestibility accounted for nearly all the variation in dry matter intake. The exponents relating body weight and fecal output to feed intake were 0.99 for body weight and 1.01 for fecal dry matter. As dry matter digestibility increased, dry matter intake increased. Forty-two per cent of the variation in dry matter consumption between cows on the same ration was explained by differences in rate of passage. On diets above 66% digestibility, metabolic size, milk energy produced and digestibility accounted for 83% of the variation in intake. Consumption decreased with increasing digestibility. At the peak of lactation the exponent relating dry matter intake to body weight was 0.73.

McCullough and Russel (1962) showed that above 65% digestibility, the influence of digestibility on intake decreased. Karue <u>et al</u>. (1973) determined that 62% of the variation in voluntary consumption was from differences in body weight when feeding varying levels of concentrate with poor quality hay (7% crude protein, 80% cell wall constituents) to steers. As per cent concentrate increased, effect of body weight decreased. When dry matter intake was expressed as $DMI=A(BW)^b$, b was influenced by diet quality. Van Soest (1965) expresses the same idea in terms of chemical composition. When cell wall constituents are greater than 50-60% of forage dry matter, intake is highly correlated with dry matter digestibility. When forages have a low per cent of cell wall constituents, digestibility and intake are less closely related.

When intake is limited by physical capacity, a cow does not consume forage to match her needs for maintenance and milk production. Instead milk production and weight change will depend on consumption regulated primarily by forage quality. On highly digestible diets when intake is controlled by physiological factors, energy requirements for maintenance and production will govern intake.

Hereford-Holstein crossbred cows grazing native range (predominantly little bluestem-Andropogan scorparius) in Oklahoma during June (digestibility of dry matter was 62%) consumed the same amount of forage (2.5% of body weight) as Hereford cows of similar weight even though they were producing 3 kg more milk per day (Lusby et al., 1976). Spring calving cows grazing crested wheatgrass (Agropyrion desertorium) in eastern Oregon during the summer consumed the same amount of forage as fall calving cows even though they were producing 2.33 to 3.13 kg more milk per day. Fall calving cows gained more or lost less throughout the study (Kartchner et al., 1979).

> Fundamental to an understanding of feed intake regulation is the concept that feed intake is not an independent variable, since animals obtain all of the energy transferred to heat, work and storage (includes growth, fat deposition and milk) from the feed. Any one of these physiological functions may change in magnitude relative to the other. It is apparent, therefore, that the variables are regulated individually as well as together. (Conrad, 1966)

Influence of body condition on forage intake

The gastro-intestinal tract can be easily stretched to fill the body cavity (Balch and Campling, 1962; Warner, 1961). Anything that restricts the space in the body cavity could be expected to limit intake of forages. Taylor (1959) got a significant negative correlation between fecal production and weight of internal fat and a significant partial correlation between fill and internal fat when carcass weight was held constant. Donelly et al. (1974) found that with grazing or pen fed wethers, body condition had little effect until body fat content was 20% of fasted weight. Bines et al. (1969) showed fat cows consumed less hay (57-60.1% dry matter digestibility) than thin cows. Cows previously on a lower level of nutrition tended to consume more forage and gain more weight the following summer on native range in Oklahoma (Lusby et al., 1976). Sheep consumed more pasture forage if they had previously grazed a poor quality pasture compared to sheep previously grazing a higher quality pasture (Langlands, 1978).

Beef cows of similar frame size, might have a decrease in forage consumption with increasing body weight when the added weight is fat.

Influence of pregnancy on forage intake

Ewes carrying twins or triplets consume less forage than ewes carrying singles (Hadjipieris and Holmes, 1966). When the organic matter digestibility was greater than 70%, Arnold (1975) observed pregnant or lactating ewes consumed more forage than dry ewes in response to greater energy requirements. Lamberth (1969) observed that heifers in the last six weeks of pregnancy consumed less forage than their non-pregnant twins. Campling (1966) also showed reduced hay intake during late pregnancy of heifers.

Influence of concentrate supplement on forage intake

Urea or casein has been shown to increase intake and digestibility of low quality forages (Campling et al., 1962; Coombe and Tribe, 1963). Supplementing low quality forages with crude protein up to dietary levels of 10% has increased ad libitum intake and crude fiber and crude protein digestibility (Weston, 1967; Lyons et al., 1970; Crabtree and Williams, 1971 a and b). Coombe and Tribe (1963) observed that feeding urea with straw increased rate of cellulose digestion and rate of passage through the gut. Rittenhouse et al. (1970) reported increased digestibility of forage by cattle grazing mixed winter range in Nebraska when supplemented with 3.00 grams crude protein per unit of metabolic size when compared to lower levels of protein (forage crude protein = 5.3%). In another trial supplementing with 2.07 grams crude protein per unit of metabolic size also gave slightly higher forage digestibilities than no protein supplement (forage crude protein = 5.6%). In neither trial was forage intake increased. Total dietary intake and digestibility increased as level of supplementary energy increased. Forage intake was depressed when greater than .041 megacalories of digestible energy per unit of metabolic size was fed. Cows grazing dormant winter range (predominantly little bluestem-*Andropogan scorparius*) in Oklahoma consumed less forage as level of a 30% crude protein supplement increased from .047 to .097 megacalories per unit of metabolic size (Lusby et al., 1976).

Feeding soybean meal with low quality hay (4.5% crude protein) increased intake until soybean meal was 20% of the diet. Higher levels decreased forage consumption (Crabtree and Williams, 1971 b). Crabtree and Williams (1971 a) also increased intake of straw (3.9% crude protein) by feeding a 19.1% crude protein concentrate up to 25% of the diet, but feeding any level of concentrate depressed hay consumption (6.7% crude protein) even though both were of similar digestibility. When Mulholland et al. (1976) fed varying levels of starch with straw-urea diets, feeding greater than 30% starch decreased cellulose digestibility. Blaxter et al. (1961) reported that as digestibility of the forage increased, depression of ad libitum intake by concentrate feeding also increased.

Feeding a small amount of a high protein concentrate to cattle on dormant winter pasture should increase forage consumption and digestibility. Feeding excessive amounts of concentrate will increase total dietary energy and decrease forage intake and fiber digestibility. The level at which a concentrate will begin to depress forage consumption will depend on the amount of available protein and digestibility of the forage.

Influence of selective grazing on forage intake and diet quality

Rao (1972) found that samples of native Flint Hills pasture collected with esophageally fistulated steers was higher in crude protein and lower in crude fiber than hand clipped samples wether expressed on a dry matter or organic matter basis. Esophageally collected samples were also higher in in vitro dry matter and organic matter digestibility. Smith et al. (1959) showed that samples plucked following steers to estimate the diet consumed was higher in crude protein and lower in crude fiber compared to plot clippings of Flint Hills range. Edelefsen et al. (1960) found esophogeal samples collected with sheep higher in crude protein and phosphorous and lower in lignin and cellulose than hand clipped samples even after correcting for salivary contamination. This indicates that grazing ruminants select diets of higher quality than the average of the forage available. Sheep grazing semi-arid range in Argentina selected from species comprising less than one-fourth of all forage available and the predominate species consumed changed with the season (Bishop, et al., 1957).

> The opportunity for selective grazing will depend on the availability of different plant species, leaf to stem proportion and total supply of forage available. Furthermore, it appears that dry matter intake is related to the amount of selective grazing (Fontenot and Blaser, 1965).

Blaser et al. (1960) observed decreased forage availability and less selective grazing on heavily stocked pastures. Arnold and Dudzinski (1967) found about 40% of the variation in digestible organic matter intake was due to total dry matter available per acre. Diet digestibility and leaf length of Phalaris tuberosa and Trifolium subterraneum also accounted for variation in digestible organic matter intake. Langlands (1968) showed a positive correlation between herbage availability and forage intake. Allden and Whittaker (1970) concluded that plant height was more closely related to consumption than just forage availability. They found that size of bite increased linearly with plant height up to a point. As herbage availability decreased, time spent grazing increased until levels of available forage were so low sheep were unable to compensate with enough grazing time. Donnelly et al. (1974) also observed that sheep on sparse pasture grazed longer than those on abundant pasture.

Influence of plant maturity on forage intake and diet quality

As the plant matures there is an increase in cell wall constituents and an increase in lignification of the cell wall. Woolfolk et al. (1973 and 1975) used esophageally fistulated steers to evaluate native Flint Hills range. All figures were reported on an ash-free dry matter basis. Crude protein declined monthly June through September (12.45 to 9.72%) then increased in October (10.23%). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) increased from June to September (82.99 to 85.84%, 47.76 to 55.26%) then declined in October (76.05, 52.27%) when cool season grasses appeared. Per cent lignin of the ADF fraction increased from June through September (19.90 to 27.20%). Apparent dry matter digestibility decreased from June to August (52.33 to 46.16%) then increased from September to October (46.88 to 48.33%).

Rao et al. (1973) evaluated the same native pasture and observed similar monthly trends in crude protein. *In vitro* dry matter digestibility and organic matter digestibility were similar for June and July then decreased through October. Rao et al. (1974 a) harvested hay from Flint Hills range in June, July and September. Dry matter consumption, organic matter intake and digestibility of NDF, hemicellulose and cellulose declined from June to September.

When Blaxter (1961) fed hay cut at three stages, as maturity increased dry matter consumption decreased, rumen transit time increased, but rumen fill upon slaughter was similar. Native vegetation and introduced species in Oregon decreased in crude protein and phosphorous and increased in lignin, cellulose, and crude fiber as the season advanced from May to September. Digestibility of nitrogen, cellulose, gross energy and dry matter decreased with corresponding decreases in digestible nitrogen and energy intake (Raleigh, 1970). Others have shown similar changes of plant composition and animal consumption with advancing maturity of pasture forage (Cogswell and Kamstra, 1976; Cook and Stoddart, 1961; Rosiere, et al., 1975; Streeter et al., 1974).

Holloway et al. (1979) compared cows grazing mature tall fescue to those grazing tall fescue kept in the vegetative stage by frequent clipping. Dry matter digestibility and forage consumption were less for those grazing mature pasture. Although cows on both forages produced similar amounts of milk, cows grazing the higher quality forage produced milk of higher butterfat content, heavier calves at weaning and gained more weight and subcutaneous fat.

Determination of forage intake by grazing ruminants

When forage consumption cannot be directly measured, the following equation makes an estimate possible.

$$\text{Herbage intake (g DM/day)} = \frac{\text{fecal output (g DM/day)}}{\text{indigestibility of dry matter (\%)}}$$

(Smith and Reid, 1955)

Fecal output can be determined directly by total collection. This method is time consuming and not practical for females or large numbers of animals under range conditions. External indicators such as chromic oxide have been used to estimate fecal output with the following equation.

$$\text{Fecal dry matter output (g)} = \frac{\text{g external indicator fed x 100}}{\text{\% external indicator in feces grab sample dry matter}}$$

(Crampton and Harris, 1969)

Chromic oxide has been the most widely used external indicator, but concentration of chromium in the feces varies with the time of day (Putnam et al., 1958; Raymond and Minson, 1955). Concentration of chromium in the feces can range from 65 to 141% of the mean during a 24 hour period (Smith and Reid, 1955). Many researchers have sampled two times a day at equidistant points above and below the mean concentration to overcome diurnal variation (Lambourne and Reardon, 1962 a; Hardison et al., 1959; Kane et al., 1952). Since the pattern of excretion is influenced by forage quality, rate of passage, time of forage intake, time of administration and manner of administration (Hopper et al., 1978; Hardison and Reid, 1953; Lambourne, 1957), a constant time for fecal grab sampling cannot apply to all situations.

Diurnal variation can be reduced by increased frequency of bolusing (Hardison et al., 1956). Brisson et al. (1957) determined that if equal amounts of chromic oxide were given six times a day, grab samples could be taken at any time. For conditions where frequency of bolusing and fecal sampling must be limited, either the pattern of excretion must be determined or sampling can be done at any hour if the recovery rate for that particular time is known (Hardison and Reid, 1953).

Balch et al. (1957) discussed the reasons for the intra-day variation and recommended that grab samples be checked with total collections for a specific experiment. This would also eliminate inaccuracies due to incomplete recovery from other causes. Stevenson (1962) showed a 85.4 to 100.7% recovery of chromium in total collections and attributed losses to grinding and chemical determinations.

A period of seven days of chromic oxide administration has normally been used before fecal sampling begins. Lancaster et al. (1953) obtained good results when a period of only five days elapsed between initial dosing and first sampling. Lambourne (1957) observed that it took only three to four days dosing to obtain a stable level of chromium in the feces. Hardison et al. (1959) found that chromium was stable after three to seven days. Differences in the amount of time required to get stable levels of chromium are probably due to the differences in rate of passage of the feedstuffs used.

Accuracy of intake estimated increases at a decreasing rate as number of days during which feces is collected increases (Smith and Reid, 1955). Lambourne and Reardon (1962 a) found that fecal output estimated from grab samples bulked for five to seven days was 102% of the actual figure. Hardison and Reid (1953) observed that between day variation in forage intake was considerable. They suggested that intake over several days was more meaningful although a relatively accurate estimate may be made for even a single day.

Indigestibility of the grazed forage (1-digestibility) can be determined by the ratio technique, fecal index, Van Soest's summative equation (Van Soest, 1967) or two stage *in vitro* digestion.

The ratio technique employes a naturally occuring indicator in the herbage and the following equation.

$$\text{\% digestibility of dry matter} = 100 - \left(100 \times \frac{\text{units of indicator/g forage DM}}{\text{units of indicator/g feces DM}}\right)$$

Chromogens have been successfully used with green forages (Reid et al., 1952) and lignin with mature forages (Cook and Harris, 1951). Acid detergent lignin gives a higher per cent recovery and a more valid estimate of digestibility than permanganate lignin (Wilson et al., 1971). Silica has been used successfully to determine digestibility of pen fed animals but not under pasture conditions (Gallup et al., 1945; McManus et al., 1967).

To use the fecal index method it is necessary to clip forage and feed it in a conventional digestion trial. The indicator in the feces is measured and a regression equation relating digestibility to the concentration of the indicator is derived (Crampton and Harris, 1969). Use of the regression equation is limited to the specific forage fed. If year round forage intake is to be determined, one equation could not apply to all seasons. A nitrogen regression equation has given good results in determining forage digestibility (Streeter et al., 1971; Wallace and Van Dyne, 1970; Rao et al., 1974 b). McManus et al. (1967) found no improvement by adding copper, magnesium and silica to a nitrogen regression equation. Wallace and Van Dyne (1970) concluded that fecal nitrogen regression and lignin ratio were equally reliable if fecal lignin was corrected for apparent digestibility. Lambourne and Reardon (1962 b) used chromium oxide and fecal nitrogen to determine pen fed forage intake at 97% of the true figure. Bohman and Lesperance (1967) recommended that hand clipped samples used to determine fecal index equations was valid only when the pasture forage is relatively uniform and palatable. Since range forage is usually heterogeneous, they suggested internal indicator techniques to be superior.

Van Soest's (1967) summative equation requires forage samples, collected esophageally, to be analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). Per cent digestible organic matter (DOM) is then figured from the following equation. DOM = 0.98S + W (1.473 - 0.789 log L) - 12.9 where S is the percentage of neutral detergent solubles, W the percentage NDF and L the ADL expressed as a percentage of the ADF.

The Tilley and Terry (1963) two stage in vitro digestion of esophageally collected samples is probably the easiest method to determine forage digestibility. But the influence of level of intake, rate of passage and physiological conditions on digestibility cannot be accounted for. Langlands (1968) got similar estimates of forage digestibility from in vitro dry matter disappearance and fecal nitrogen regression.

Rao et al. (1974 b) showed that a fecal nitrogen organic matter equation provided a valid estimate of in vivo organic matter digestibility and intake of native Flint Hills hay. Two stage in vitro digestion gave a slightly lower value compared to actual intake. Van Soest's summative equation and the lignin ratio method (permangenate lignin) were poor indicators of digestibility and intake when used in conjunction with total collection of feces. Fecal lignin was not corrected for apparent digestibility.

Cordova et al. (1978), Harris et al. (1967), Rao (1972) and Schneider et al. (1955) have more thoroughly reviewed methods for estimation of forage consumption by grazing ruminants.

No method of determining forage intake of grazing cattle is perfect. Preliminary research should include comparisons of methods for the particular situation. The number of days for administration of external markers prior to grab sampling and the number of grab samples necessary should be determined.

Ideally, estimation of fecal output should be checked with total collection of a few animals involved in the trial. Checking digestibilities with pen fed animals is not completely valid since clipped samples may not be representative of the forage consumed under grazing conditions. Comparison of several methods will give an indication of their agreement. Then the objective of the study should govern the choice. Further research needs to be done with the use of rare earth metals as an external marker, as has been used in pen fed digestibility studies, and silica as an internal marker.

LITERATURE CITED

Allden, W.G. and I.A. McD. Whittaker. 1970. The determinants herbage intake by grazing sheep: The interrelationships of factors influencing herbage intake and availability. Aust. J. Agric. Res. 21:755.

Arnold, G.W. 1975. Herbage intake and grazing behavior in ewes of four breeds at different physiological states. Aust. J. Agric. Res. 18:657.

Arnold, G.W. and M.L. Dudzinski. 1967. Studies on the diet of grazing animals. II The effect of physiological status in ewes and pasture availability on herbage intake. Aust. J. Agric. Res. 18:349.

Balch, C.C. and R.C. Campling. 1962. Regulation of voluntary intake in ruminants. Nutr. Abstr. and Rev. 32:669.

Balch, C.C., J.T. Reid and J.W. Stroud. 1957. Factors influencing the rate of excretion of administered chromium sesquioxide by steers. Brit. J. Nutr. 11:184.

Baumgardt, B.R., M.J. Montgomery, K.S. Simkins and J.W. Suttle. 1964. Distention versus chemostatic regulation of food intake in ruminants. J. Dairy Sci. 47:865. (Abstr.)

Bines, J.A., S. Suzuki and C.C. Balch. 1969. The quantitative significance of long term regulation of food intake in the cow. Brit. J. Nutr. 23:695.

Bishop, J.P., J.A. Froseth, H.N. Verettoni and C.H. Noller. 1957. Diet and performance of sheep on rangeland in semi-arid Argentina. J. Range Manage. 28:52.

Blaser, R.E., R.C. Hammes, Jr., H.T. Bryant, W.A. Hardison, J.P. Fontenot and R.W. Engel. 1960. The effect of selective grazing on animal output. Proc. Int. Grassl. Congr. 8:601.

Blaxter, K.L., F.W. Wainman and R.S. Wilson. 1961. The regulation of food intake by sheep. Anim. Prod. 3:51.

Blaxter, K.L., and R.S. Wilson. 1962. The voluntary intake of roughages by steers. Anim. Prod. 4:351.

Bohman, V.R. and A.L. Lesperance. 1967. Methodology research for range forage evaluation. J. Anim. Sci. 26:820.

Brisson, G.J., W.J. Pigden and P.E. Sylvester. 1957. Effect of frequency of administration of chromic oxide on its fecal excretion pattern by grazing cattle. Can. J. Anim. Sci. 37:90.

Campling, R.C. 1966. A preliminary study of the effect of pregnancy and lactation on the voluntary intake of food by cows. Brit. J. Nutr. 20:25.

Campling, R.C. and C.C. Blach. 1961. Factors affecting the voluntary intake of food by cows. 1. Preliminary observations of the effect on the voluntary intake of hay, of changes in the amount of reticulo-ruminal contents. Brit. J. Nutr. 15:523.

Campling, R.C., M. Freer and C.C. Balch. 1961. Factors affecting the voluntary intake of food by cows. 2. The relationship between voluntary intake of roughages, the amount of digesta in the reticulo-rumen and the rate of disappearance of digesta from the alimentary tract. Brit. J. Nutr. 15:531.

Campling, R.C., M. Freer and C.C. Balch. 1962. Factors affecting the voluntary intake of food by cows. 3. The effect of urea on the voluntary intake of straw. Brit. J. Nutr. 16:115.

Cogswell, C. and L.D. Kamstra. 1976. The stage of maturity and its effect upon the chemical composition of four native range species. J. Range Manage. 29:460.

Conrad, H.R. 1966. Symposium on the factors influencing the voluntary intake of herbage by ruminants: Physiological and physical factors limiting feed intake. J. Anim. Sci. 25:227.

Conrad, H.R., A.D. Pratt and J.W. Hibbs. 1964. Regulation of feed intake in dairy cows. I. Change in importance of physical and physiological factors with increasing digestibility. J. Dairy Sci. 47:54.

Cook, C.W. and L.E. Harris. 1951. A comparison of the lignin ratio technique and the chromogen method of determining digestibility and the forage consumption of desert range plants by sheep. J. Anim. Sci. 10:565.

Cook, W.C. and L.A. Stoddart. 1961. Nutrient intake and livestock responses on seeded foothill ranges. J. Anim. Sci. 20:36.

Coombe, J.B. and D.E. Tribe. 1963. The effects of urea supplement on the utilization of straw plus molasses diets by sheep. Aust. J. Agric. Res. 14:70.

Cordova, F.J., J.D. Wallace and R.D. Pieper. 1978. Forage intake by grazing livestock: A review. J. Range Manage. 31:430.

Crabtree, J.R. and G.L. Williams. 1971 a. The voluntary intake and utilization of roughage-concentrate diets by sheep. 1. Concentrate supplements for hay and straw. Anim. Prod. 13:71.

Crabtree, J.R. and G.L. Williams. 1971 b. The voluntary intake and utilization of roughage concentrate diets by sheep. Anim. Prod. 13:83.

Crampton, E.W. 1957. Interrelations between digestible nutrient and energy content, voluntary dry matter intake, and overall feeding value of forages. J. Anim. Sci. 16:546.

Crampton, E.W. and L.E. Harris. 1969. Applied Animal Nutrition. W.H. Freeman and Co., San Francisco.

Dinius, D.A. and B.R. Baumgardt. 1970. Regulation of food intake by ruminants. 6. Influence of caloric density of pelleted rations. J. Dairy Sci. 53:311.

Donnelly, J.R., J.L. Davidson and M. Freer. 1974. Effect of body condition on the intake of food by mature sheep. Aust. J. Agric. Res. 25:813.

Dowden, D.R. and D.R. Jacobsen. 1960. Inhibition of appetite in dairy cattle by certain intermediate metabolites. Nature 188:148.

Edelefsen, J.L., C.W. Cook and J.T. Blake. 1960. Nutrient content of the diet as determined by hand plucked and esophageal fistula samples. J. Anim. Sci. 19:560.

Freer, M. and R.C. Campling. 1963. Factors affecting the voluntary intake of food by cows. Brit. J. Nutr. 17:79.

Fontenot, J.P. and R.E. Blaser. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: Selection and intake by grazing animals. J. Anim. Sci. 24:1202.

Gallup, W.D., C.S. Hobbs and H.M. Briggs. 1945. The use of silica as a reference substance in digestion trials with ruminants. J. Anim. Sci. 4:68.

Gill, S.S., H.R. Conrad and J.W. Hibbs. 1969. Relative rate of in vitro cellulose disappearance as a possible estimator of digestible dry matter intake. J. Dairy Sci. 52:1687.

Hadjipieris, G. and W. Holmes. 1966. Studies on feed intake and feed utilization by sheep. I The voluntary feed intake of dry, pregnant and lactating ewes. J. Agric. Sci. 66:217.

Hardison, W.A., R.W. Engel, W.N. Linkous, H.C. Sweeney and G.C. Graf. 1956. Fecal chromic oxide concentration in 12 dairy cows as related to time and frequency of administration and to feeding schedule. J. Nutr. 58:11.

Hardison, W.A., W.N. Linkous, R.W. Engel and G.C. Grad. 1959. Observations on the use of chromic oxide for estimating the fecal output of dairy animals. J. Dairy Sci. 42:346.

Hardison, W.A. and J.T. Reid. 1953. Use of indicators in measurement of the dry matter intake of grazing animals. J. Nutr. 51:35.

Harris, L.E., G.P. Lofgreen, C.J. Kercher, R.J. Raleigh and V.R. Bohman. 1967. Techniques of research in range livestock nutrition. Utah State Univ. Agr. Exp. Sta. Bull. 471.

Holloway, J.W., W.T. Butts, Jr., J.D. Beaty, J.T. Hopper and N.S. Hall. 1979. Forage intake and performance of lactating beef cows grazing high or low quality pastures. J. Anim. Sci. 48:692.

Hopper, J.T., J.W. Holloway and W.T. Butts, Jr. 1978. Animal variation in chromium sesquioxide excretion patterns of grazing cows. J. Anim. Sci. 46:1096.

Kane, E.A., W.C. Jacobson and L.A. Moore. 1952. Diurnal variation in the excretion of chromium oxide and lignin. J. Nutr. 47:263.

Kartchner, R.J., L.R. Rittenhouse and R.J. Raleigh. 1979. Forage and animal management implications of spring and fall calving. J. Anim. Sci. 48:425.

Karue, C.N., J.L. Evans and A.D. Tillman. 1973. Voluntary intake of dry matter by African Zebu cattle. Quality of feed and the reference base. J. Anim. Sci. 36:1181.

Lamberth, J.L. 1969. The effect of pregnancy in heifers on voluntary intake, total rumen contents, digestibility and rate of passage. Aust. J. Exp. Agric. Anim. Husb. 9:493.

Lambourne, L.J. 1957. Measurement of feed intake of grazing sheep. II Estimation of faeces output using markers. J. Agric. Sci. 48:415.

Lambourne, L.J. and T.F. Reardon. 1962 a. The use of chromium oxide to estimate the fecal output of merinos. Aust. J. Agric. Res. 14:249.

Lambourne, L.J. and T.F. Reardon. 1962 b. The use of chromium oxide and faecal nitrogen concentration to estimate the pasture intake of merino wethers. Aust. J. Agric. Res. 14:257.

Lancaster, R.J., M.R. Coup and J.C. Perceval. 1953. Measurement of feed intake by grazing cattle and sheep. III Marker technique for investigating the faeces output of grazing cows. N. Z. J. Sci. Tech. 35:117.

Langlands, J.P. 1968. The feed intake of grazing sheep differing in age, breed, previous nutrition and live weight. J. Agric. Sci. 71:167.

Lusby, K.S., D.F. Stephens and R. Totusek. 1976. Influence of breed and level of winter supplement on forage intake of range cows. J. Anim. Sci. 43:543.

Lyons, T., R.J. Caffrey and W.J. O'Connell. 1970. The effect of energy, protein and vitamin supplementation on the performance and voluntary intake of barley straw by cattle. Anim. Prod. 12:323.

Manning, R., G.I. Alexander, H.M. Krueger and R. Bogart. 1959. The effect of intravenous glucose injections of appetite in adult ewes. Am. J. Vet. Res. 20:242.

McCullough, M.E. and J.R. Russell. 1962. Forage and nutritional factors influencing potential and economic use of forage for dairy cattle. J. Anim. Sci. 21:1036 (Abstr.).

McManus, W.R., M.L. Dudzinski and G.W. Arnold. 1967. Estimation of herbage intake from nitrogen, copper, magnesium and silicon concentration in feces. J. Agric. Sci. 69:263.

Montgomery, M.J. and B.R. Raumgardt. 1965. Regulation of food intake in ruminants. I Pelleted rations varying in energy concentration. J. Dairy Sci. 48:569.

Mulholland, J.G., J.B. Coombe and W.R. McManus. 1976. Effect of starch on utilization by sheep of a straw diet supplemented with urea and minerals. Aust. J. Agric. Res. 27:139.

Putnam, P.A., J.K. Loosli and R.G. Warner. 1958. Excretion of chromium oxide by dairy cows. J. Dairy Sci. 41:1723.

Rao, M.R. 1972. Nutritive evaluation of forage selected by cattle on Flint Hills range. M.S. Thesis. Kansas State Univ., Manhattan.

Rao, M.R., L.H. Harbers and E.F. Smith. 1973. Seasonal change in nutritive value of bluestem pasture. J. Range Manage. 26:419.

Rao, M.R., L.H. Harbers and E.F. Smith. 1974 a. Estimating intake and digestibility of native Flint Hills hay. J. Range Manage. 27:20.

Rao, M.R., L.H. Harbers and E.F. Smith. 1974 b. Estimating consumption and digestibility in steers fed native Flint Hills hay-methods compared. Trans. Kans. Acad. Sci. 77:36.

Raleigh, R.J. 1970. Symposium on pasture methods for maximum production in beef cattle: manipulation of both livestock and forage management to give optimum production. J. Anim. Sci. 30:109.

Raymond, W.F. and D.J. Minson. 1955. The use of chromic oxide for estimating the faecal production of grazing animals. J. Brit. Grassl. Soc. 10:282.

Reid, J.T., P.G. Woolfolk, W.A. Hardison, C.M. Martin, A.L. Brundage and R.W. Kaufman. 1952. A procedure for measuring the digestibility of pasture forage under grazing conditions. J. Nutr. 46:255.

Rittenhouse, L.R., D.C. Clanton and C.L. Streeter. 1970. Intake and digestibility of winter range forage by cattle with and without supplement. J. Anim. Sci. 31:1215.

Rook, J.A.F., C.C. Balch and R.C. Campling. 1960. The effect of intraruminal infusions of acetic, propionic and butyric acids on nitrogen retention in growing heifers. Proc. Nutr. Soc. 19:1.

Rosiere, R.E., J.D. Wallance and R.F. Beck. 1975. Cattle diets on semidesert grassland: Nutritive content. J. Range Manage. 28:94.

Schneider, B.H., B.K. Soni and W.E. Ham. 1955. Methods for determining consumption and digestibility of pasture forage. Wash. Agr. Exp. Sta. Tech. Bull. 16.

Smith, A.M. and J.T. Reid. 1955. Use of chromic oxide as an indicator of fecal output for the purpose of determining the intake of pasture herbage by grazing cows. J. Dairy Sci. 38:515.

Smith, E.F., V.A. Young, L.A. Holland and H.C. Fryer. 1959. A comparison of two grass sampling methods for digestibility trials conducted on pasture. J. Range Manage. 12:306.

Stevenson, A.E. 1962. Measurement of feed intake by grazing cattle and sheep. N. Z. J. Agric. Res. 5:339.

Streeter, C.L., C.B. Rumburg, T.H. Halland and E.G. Siemer. 1974. Meadow forage quality, intake and milk production of cows. J. Range Manage. 27:133.

Streeter, C.L., G.H. Scales and A.H. Denham. 1971. Estimating the digestibility of grazed forage. J. Anim. Sci. 33:246.

Taylor, J.C. 1959. A relationship between weight of internal fat, fill and the herbage intake of grazing cattle. Nature 184:2021.

Tilley, J.M.A. and R.A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Brit. Grassl. Soc. 18:104.

Van Soest, P.J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: Voluntary intake in relation to chemical composition and digestibility. J. Anim. Sci. 21:834.

Van Soest, P.J. 1967. Development of a comprehensive system of feed analysis and its application to forages. J. Anim. Sci. 26:119.

Wallace, J.D. and G.M. Van Dyne. 1970. Precision of indirect methods for estimating digestibilities of forage consumed by grazing cattle. J. Range Manage. 23:424.

Warner, R.G. 1961. Is hay required to develop rumen capacity? J. Dairy Sci. 44:1177 (Abstr.).

Weston, R.H. 1967. Factors limiting the intake of feed by sheep. II Studies with wheaton hay. Aust. J. Agric. Res. 18:983.

Wilson, A.D., W.C. Weir and D.T. Torrell. 1971. Comparison of methods of estimating the digestibility of range forage and browse. J. Anim. Sci. 32:1046.

Woolfolk, J.S. 1973. Effect of nitrogen fertilization and late spring burning on diet and performance of yearling steers grazing native bluestem range. M.S. Thesis. Kansas State Univ., Manhattan.

Woolfolk, J.S., E.F. Smith, R.R. Schalles, B.E. Brent, L.H. Harbers and C.E. Owensby. 1975. Effects of nitrogen fertilization and late spring burning of bluestem range on diet and performance of steers. J. Range Manage. 28:190.

FORAGE INTAKE AND PERFORMANCE OF RANGE COWS AS AFFECTED BY DELAYED WINTER SUPPLEMENTAL FEEDING AND MINERAL SUPPLEMENTATION

SUMMARY

Seventy-three spring calving Polled Hereford cows grazing native Flint Hills pasture were used to determine monthly forage intake and the effect of delayed winter supplemental feeding and year round mineral supplementation. Cows in three pastures were fed 1.4 kg alfalfa hay per cow daily from November 1 to April 6 with an additional 2.7 kg sorghum grain from February 15 to April 6. Cows in three other pastures on delayed feeding were fed 1.4 kg alfalfa hay and 2.7 kg sorghum grain per cow daily from February 1 to April 6. One pasture of each supplemental group was offered a salt-mineral mixture balanced for sodium, phosphorous, potassium and copper deficiencies in the grazed forage. The other pastures received salt _ad libitum_.

Forage dry matter intake was determined for 52 cows monthly by the excretion-to-indigestibility ratio using chromic oxide as an external marker and _in vitro_ dry matter digestibility of the grazed forage. Correction factors for incomplete recovery of chromium due to the time of sampling were determined by dividing the chromium concentrations in the fecal grab samples of 4 steers by the chromium concentration in total fecal collections from the same steers.

Forage consumption was not affected by winter supplement program but was slightly higher when the salt-mineral mixture was fed. Forage intake ranged from 8.12 kg (1.70% of fall weight) in November to 16.83 kg (3.45% of fall weight) in June. Four and five year olds consumed more forage than other age groups even though adjusted for fall weight. Forage intake increased with cow weight but was not affected by level of milk production.

Cows not supplemented until February lost more weight from November to February and were in poorer condition one month prior (February 2) to the beginning of the calving season. Weight gains during February were greater for cows on delayed supplemental feeding. Body condition at the beginning of calving, weight loss from calving to breeding and total winter weight loss were similar. Birth weights, weaning weights and reproductive performance were similar for both groups. Providing a salt-mineral mixture did not improve reproduction, calf performance or summer weight gain. Winter weight loss was increased when minerals were fed.

INTRODUCTION

Information is limited on the amount of forage consumed by grazing cattle. Woolfolk (1973) and Rao et al. (1974) determined forage intake for steers grazing native range in the Kansas Flint Hills during the summer. One of the objectives of this study was to determine the levels of forage consumed by mature cows year round and some of the factors affecting consumption.

Davis et al. (1977) summarized feeding trials for cows grazing native range in the Flint Hills. Spring calving cows maintained adequate reproduction if supplemented with 1.4 kg of alfalfa hay during the winter, with an additional 2.7 kg of sorghum grain beginning 100 days prebreeding. Flint Hills forage is below NRC (1976) recommendations for sodium, phosphorous, and copper year round and deficient in potassium during the winter (Harbers et al., 1978). The cows in this study were used to determine if supplemental feeding early in the winter could be eliminated and if balancing the diet for deficient minerals is beneficial.

MATERIALS AND METHODS

During the winter of 1977-78 73 Polled Hereford cows maintained at the Kansas State University Range Research Unit near Manhattan, Kansas, grazed six native Flint Hills pastures (described by Anderson and Fly, 1955) with 2.8 hectares per cow. Cows in three pastures were fed an average of 1.4 kg alfalfa hay (1-00-63) per cow daily from November 1 to April 6 and in addition, an average of 2.7 kg sorghum grain (4-04-383) daily per head from February 15 to April 6. Cows in the other three pastures were fed an average of 1.4 kg alfalfa hay and 2.7 kg sorghum grain per cow daily from February 1 to April 6. During periods of long snow cover alfalfa hay was fed to all cows. The following summer 63 of the same cows grazed the pastures with 3.1 hectares per cow. One pasture of each winter supplement group received a mineral mixture formulated to meet NRC (1976) requirements for salt, potassium, phosphorous and copper. Forage mineral analysis reported by Harbers et al. (1978) was used and forage dry matter intake was estimated to be 7.5 kg for November through April and 13.6 kg for May through October. Content and intake of the mineral mixture are given in Table 1. Cows in the other four pastures received salt ad libitum. During the winter soybean meal (5-04-604) was added when necessary to insure desired mineral consumption. Equal amounts of soybean meal were added to all pastures.

Calves were born from February 24 to May 11 and weaned on October 5 at an average age of 195 days. Cows were exposed to Polled Hereford bulls for 60 days beginning May 25. Monthly cow weights were recorded near the first of the month after being fasted overnight.

Forage intake was measured for 52 cows in four pastures in November, December and monthly from March through October. Chromium oxide (25g per head per day) was administered once daily (7:00 - 10:00 a.m.) in gelatin capsules for 4 days prior to and for the first 3 days of a 4 day collection period when fecal grab samples were collected at the time of bolusing. Grab samples were composited over 4 days for each individual.

To determine the recovery rate of chromium, 4 steers were maintained in 2 of the pastures and bolused and collected with the cows. These steers were also harnassed with fecal collection bags and total feces was collected for 24 hours on alternate days of the collection period. Total collections were weighed, mixed and approximately 2000 grams kept for analysis.

All fecal samples were stored frozen; dried at 55^{o}C; ground in a Wiley mill (40-mesh screen); and stored in glass bottles until laboratory analysis. Samples were wet ashed with nitric acid and perchloric acid digestion. Three ml of 48% hydroflouric acid were added to the wet ash solution to dissolve silica. Chromium was determined by spectrophotometry at λ= 452 nm. Air dried fecal samples were vacuum dried and chromium concentrations adjusted to 100% dry matter.

Recovery rates of chromium in the total collections were calculated by dividing the grams of chromium bolused (15.69) by the grams of chromium excreted in 24 hours (from total collections). The recovery rates of chromium in the grab samples were calculated by dividing the concentration of chromium in the grab samples by the concentration of chromium in the total collection from the same steer.

Based on digestion coefficients reported by Morrison (1961), 1.4 kg of alfalfa produced .55 kg of fecal dry matter and 2.7 kg of sorghum grain produced .34 kg of fecal dry matter. Fecal dry matter output was calculated by the following formula:

$$\left(\frac{15.69 \text{ g Cr}}{\text{\% Cr in feces/monthly recovery of Cr in grab sample}} \right) - \text{feces from supplement}$$

Two stage *in vitro* dry matter digestibilities of forage samples collected with esophageally fistulated steers on the same pastures during this study are reported by Peischel (1980). It was assumed that level of supplement did not affect forage digestibility. Forage dry matter intake was calculated by dividing fecal output by forage indigestibility (1-digestibility). Individual monthly milk production determined by the weigh-suckle-weigh technique were also reported by Peischel (1980).

For statistical analysis cows were grouped as 3, 4-5, 6-7, 8-9, and 10-12 year olds. Only pregnant cows were used for analysis of forage intake from November through March and only lactating cows for April through October. Only cows weaning a calf were included in analysis of weight change and condition. Several cows were removed from the pastures if their calf died or for reasons unrelated to the study. Data was analyzed by the SAS General Linear Model procedure (Barr *et al.*, 1976) and Duncan's New Multiple Range Test was used for means separation (Steele and Torrie, 1960).

RESULTS AND DISCUSSION

The means for the per cent recovery of chromium (Cr) in the total collections and grab samples of the steers by month are shown in Table 2. Although the recovery of Cr in the total collections for individual steers ranged from 51 to 156% the mean recovery was 100.2%. Recovery in the total collections was not affected by month (P=.66), nor were any trends related to time or forage digestibility observed. The concentration of Cr in the total collections represents the mean for a 24 hour period. Since the concentration of Cr in the feces varies with the time of day (Hopper et al., 1978), the recovery of Cr in the grab samples (per cent Cr in grab sample ÷ per cent Cr in the total collection) can be used to correct for sampling at a particular time (Hardison and Reid, 1953). Recovery in the grab samples was lower ($P<.01$) for months when forage digestibility was the highest. This agrees with Hopper et al. (1978) who showed that the recovery of Cr at a particular time was influenced by pasture quality. Lambourne (1957) concluded that when external markers are administered once daily, the marker concentration in the feces peaks faster and higher, and decreases more rapidly when rate of passage is faster. Therefore the shape of the excretion curve depends on diet digestibility.

Means for daily forage intake per cow by winter supplement and mineral treatment are shown in Table 3. Winter supplement treatment did not influence forage intake nor was any month X winter supplement interaction observed. The only within month comparisons possible are in the months of November and December when half of the cows received 1.4 kg of alfalfa hay per cow daily. Supplementing a low quality forage with forage higher in crude protein should increase forage digestibility (Campling et al., 1962; Coombe and Tribe, 1963). Differences in forage intake due to digestibility would not be reflected in this study since forage digestibility was assumed to be the same for both groups.

The mean forage intake for those cows receiving salt plus mineral was slightly higher (P=.11). Dennis et al. (1976) increased feed intake by supplementing a potassium deficient diet with potassium chloride. Raising the phosphorus in a phosphorous deficient diet has also shown to increase feed intake (Long et al., 1957). There was no month X mineral treatment interaction (P=.61), but pasture within mineral influenced forage consumption ($P<.01$). This also represents a winter supplement X mineral treatment interaction but no good test of this exists since only one pasture was on a particular winter supplement-mineral treatment combination. If this interaction was valid, it would be evident in November and December when two levels of supplement were fed. Although the month X winter supplement X mineral treatment interaction approaches significance (P=.11), the greatest differences were in May and June when no supplement was offered.

Means of monthly forage intake per cow are shown in Table 4. Forage intake was the highest ($P<.001$) in the spring when forage digestibility and crude protein are the greatest. Many other researchers have shown similar seasonal trends (Rao et al., 1974; Raleigh, 1970; Cook and Stoddart, 1961). Lemenager et al. (1978) obtained similar winter values for 409.8 kg Hereford cows fed 1.25 kg of concentrate and grazing tallgrass range in Oklahoma. Lusby et al. (1976) reported Hereford cows grazing similar range in Oklahoma consumed 99 or 84 grams per kg body weight $^{.75}$ of forage dry matter in June (depending on level of winter supplement). This compares to 161.78 grams in this study even though forage digestibilities were similar. Other researchers have reported lower forage intakes (expressed as per cent of body weight) for steers consuming summer Flint Hills forage (Rao et al., 1974; Woolfolk, 1973).

A small error in either forage digestibility or recovery of Cr causes a large error in forage intake. Boggs (1977) reported monthly forage digestibilities from the same pastures used in this study for May through September. May and June values were much lower and September values higher. Woolfolk (1975) also reported a much lower value (52.06%) for June forage digestibility of Flint Hills pasture. Even though more total collections of feces need to be used to accurately predict recovery of Cr for a particular time of day, there is a definite trend for lower recovery of Cr in the grab samples in months with higher forage digestibilities. This cannot be ignored when trying to estimate forage intake.

Forage intake increased ($P<.01$) with November weight (b=.00974). Replacing November weight with November metabolic size did not increase the R^2 (both .5226). When squared and cubed terms of November weight were added, neither were significant. Level of milk production did not influence forage consumption. This agrees with Conrad et al.(1964) who reported that when dairy cows were fed roughage rations between 52 and 66% digestible, milk production had no effect on the amount of forage consumed. He also observed that dry matter intake was linear with body weight.

Means for forage intake by age are given in Table 5. Intake was influenced by age (P=.02) with four and five year olds consuming more forage than any other age group. Since beginning November weight was included in the statistical model, these differences were not expected. It is possible that there is not enough variation in weight to make accurate adjustments for weight by the regression equation. Forage intake was not adjusted for November body condition. When November weight-height ratio was included in the statistical model, it yielded an unexplainable equation. Beta values were negative for weight and positive for weight-height ratio. The narrow range of body condition in November may be the cause.

Cow weight changes and weight-height ratios are given in Table 6. Total winter weight loss and summer weight gains were similar for both winter supplement groups. But when supplemental feeding was delayed until February 1, cows lost more weight ($P<.01$) from November to February and were in poorer condition ($P=.05$) one month prior (February 2) to the beginning of the calving season. During February cows on delayed feeding maintained their weight while the early supplemented cows lost weight ($P<.001$). Since both groups were in similar condition at the beginning of the calving season (February 28), and gains up to the beginning of breeding (June 1) were not affected by winter supplement, we would expect similar reproductive performance (Whitman, 1975). Reproductive performance and calf performance are shown in Table 7. Calving interval was not influenced by winter supplement treatment and only one cow in each group did not conceive. Calf birth weight and calf weaning weight were not affected.

Cows receiving salt plus mineral lost more weight ($P=.05$) during the winter than cows receiving only salt. The greatest difference in weight change occurred from November to February ($P<.01$). Those cows offered the mineral mixture were in only slightly poorer condition one month prior (February 2) to the onset of calving, but lost less weight during February (P=.08) to have a similar weight-height ratio on February 28. Although the salt plus mineral group lost more weight (P=.08) from February 28 to June 1, weight-height ratios were similar when the breeding season began. Calf birth weight was not influenced by mineral treatment. Cows offered salt plus mineral weaned slightly heavier calves (P=.16). Calving interval was not affected by mineral treatment. Two cows in the salt plus mineral group were open in the fall.

Balancing the diet for the minerals deficient in native Flint Hills pasture did not improve performance in this study. Providing dicalcium phosphate, potassium chloride and trace minerals increased winter weight loss. This agrees with Drake et al. (1962) who observed greater weight losses for heifers grazing bluestem pasture when supplemented with dicalcium phosphate. The retention and utilization of many minerals are interrelated. Lampkim and Howard (1962) observed decreased blood hemoglobin when supplementing with dicalcium phosphate and discussed the possibility of decreased iron availability. Fontenot et al. (1960) and Kunkel et al. (1953) demonstrated reduced retention of magnesium by feeding high levels of potassium. Although the potassium levels were much higher compared to this study, so were the magnesium levels fed. High levels of calcium and phosphorous have also been shown to reduce magnesium retention (O'Dell, 1960). Cows offered salt plus mineral consumed much less salt than those offered salt ad libitum. It is possible that their sodium requirement was not being met at this level. During most of the winter 9 grams of salt will provide approximately 0.10 per cent salt in the diet dry matter recommended by NRC (1976) for beef cattle. But 9 grams will not raise the per cent sodium in the diet during the winter to the recommended 0.06 per cent.

It is also below the sodium level recommended by NRC (1978) for nonlactating dairy cows (equivalent to 0.25 per cent salt).

The means for cow weight change and weight-height ratio for winter supplement X mineral treatment interactions are shown in Table 8. The interactions for winter weight loss (P=.08), and weight changes from November 2 to February 2 (P=.05), February 2 to February 28 (P=.01) and February 28 to June 1 (P=.09) are important. Supplying salt plus mineral increased winter weight loss, but within winter supplement, the influence was less when alfalfa hay was fed early. Alfalfa hay (0.14% sodium, NRC, 1978) would increase the level of sodium in the diet slightly. Alfalfa hay (0.29% magnesium, NRC, 1978) would also raise the concentration of magnesium which is borderline in the dormant winter forage (Harbers et al., 1978). Since no magnesium was included in the mineral mixture, this is also a possible explanation for the winter supplement X mineral treatment interaction observed for November to February 2 weight change (P=.05). When winter supplement was delayed until February 1 and salt plus mineral was provided, cows gained weight during February while the other groups were losing weight. This is probably because they were in the poorest condition when concentrate feeding began instead of any beneficial effect of the minerals consumed. No interactions for calving interval, birth weight or weaning weight were observed.

In conclusion, winter supplement for cows on native Flint Hills pasture can be delayed until thirty days prior to calving if high levels of energy are fed until ample green forage is available. Reproductive performance should not be harmed for cows of similar breed type and milking potential if they are in good condition going into the winter. Less weight loss from supplementing a high protein forage during early winter was a result of additional protein and energy rather than any influence on intake of the standing forage. Correcting phosphorous, potassium and trace mineral deficiencies in the grazed forage was not beneficial. Sodium may have been deficient or the minerals provided may have reduced the availability of other minerals present in borderline quantities.

Forage intake ranged from 1.70% of fall body weight when dormant winter grass was low in protein and digestibility to 3.45% for higher protein, higher digestible forage in the spring. Forage intake increased with cow size but was not affected by the level of milk production.

LITERATURE CITED

Anderson, K.L. and C.L. Fly. 1955. Vegetation and soil relationships in Flint Hills bluestem pastures. J. Range Manage. 8:163.

Barr, A.J., G.H. Goodnight, J.P. Sall, T. Helwig. 1976. A User's Guide to SAS 76. SAS Institute Inc., Raleigh, North Carolina.

Boggs, D. 1977. Effects of milk and forage intake on calf performance. M.S. Thesis. Kansas State University, Manhattan, Kansas.

Campling, R.C., M. Freer and C.C. Balch. 1962. Factors affecting the voluntary intake of food by cows. 3. The effect of urea on the voluntary intake of straw. Brit. J. Nutr. 16:115.

Conrad, H.R., A.D. Pratt and J.W. Hibbs. 1964. Regulation of feed intake in dairy cows. I. Change in importance of physical and physiological factors with increasing digestibility. J. Dairy Sci. 47:54.

Cook. W.C. and L.A. Stoddart. 1961. Nutrient intake and livestock responses on seeded foothill ranges. J. Anim. Sci. 20:36.

Coombe, J.B. and D.E. Tribe. 1963. The effects of urea supplement on the utilization of straw plus molasses diets by sheep. Aust. J. Agric. Res. 14:70.

Davis, D., R.R. Schalles, G.H. Kiracofe and D.L. Good. 1977. Influence of winter nutrition on beef cow reproduction. J. Anim. Sci. 46:3.

Dennis, R.J., R.W. Hemken and D.R. Jacobson. 1976. Effect of dietary potassium percent for lactating dairy cows. J. Dairy Sci. 59:324.

Drake, C.L., E.F. Smith, D. Richardson, D.L. Good and D.R. Follis. 1962. The effects of feeding different levels of dicalcium phosphate to heifers on bluestem pasture. Kansas Agr. Exp. Sta. Bull. 447.

Fontenot, J.P., R.W. Miller, C.K. Whitechair and R. MacVicar. 1960. Effect of high protein, high potassium ration on the mineral metabolism of lambs. J. Anim. Sci. 19:127.

Harbers, L.H., J.E. Umoh, D.A. Raiten, V.K. Chaffin, D.A. Sapienza, B.E. Brent, A.M. Latschar, D.J. Whitney and E.F. Smith. 1978. Mineral contents of native bluestem pastures. Kansas Agr. Exp. Sta. Rpt. of Prog. 320.

Hardison, W.A. and J.T. Reid. 1953. Use of indicators in measurement of dry matter intake of grazing animals. J. Nutr. 51:35.

Hopper, J.T., J.W. Holloway and W.T. Butts, Jr. 1978. Animal variation in chromium sesquioxide excretion patterns of grazing cows. J. Anim. Sci. 46:1096.

Kunkel, T.O., K.H. Burns and B.J. Camp. 1953. A study of sheep fed high levels of potassium bicarbonate with particular reference to induced hypomagnesmia. J. Anim. Sci. 12:451.

Lambourne, L.J. 1957. Measurement of feed intake of grazing sheep. II. The estimation of faeces output using markers. J. Agr. Sci. 48:415.

Lampkin, K. and D.A. Howard. 1962. Studies on the production of beef from zebu cattle in East Africa. IV. Variation in blood haemoglobin and its response to the feeding of dicalcium phosphate. J. Agric. Sci. 59: 245.

Lemenager, R.P., F.N. Owens, K.S. Lusby and R. Totusek. 1978. Monensin, forage intake and lactation of range cows. J. Anim. Sci. 43:543.

Long, T.A., A.D. Tillman, A.B. Nelson, W.D. Gallup and B. Davis. 1957. Availability of phosphorous in mineral supplements for beef cattle. J. Anim. Sci. 16:444.

Lusby, K.S., D.F. Stephens and R. Totusek. 1976. Influence of breed and level of winter supplement on forage intake of range cows. J. Anim. Sci. 43:543.

Morrison, F.B. 1961. Feeds and Feeding-Abridged. The Morrison Publishing Co., Clinton, Iowa.

NRC. 1976. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. Fifth Revised Ed. National Academy of Science-National Research Council, Washington, D.C.

NRC. 1978. Nutrient Requirements of Domestic Animals, No. 3. Nutrient Requirements of Dairy Cattle. Fifth Revised Ed. National Academy of Science-National Research Council, Washington, D.C.

O'Dell, B.L. 1960. Magnesium requirements and its relation to other dietary constituents. Fed. Proc. 19:648.

Peischel, H.A. 1980. Factors affecting milk and grass consumption of beef calves grazing native range. Ph.D. Thesis. Kansas State University, Manhattan, Kansas.

Raleigh, R.J. 1970. Symposium on pasture methods for maximum production in beef cattle: manipulation of both livestock and forage management to give optimum production. J. Anim. Sci. 30:109.

Rao, M.R., L.H. Harbers and E.F. Smith. 1974. Estimating intake and digestibility of native Flint Hills hay. J. Range Manage. 27:20.

Steel, R.G.D. and J.H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book, Co., New York.

Whitman, R.W. 1975. Weight change, body condition and beef cow reproduction. Ph.D. Thesis. Colorado State University, Fort Collins, Colorado.

Woolfolk, J.S. 1973. Effect of nitrogen fertilization and late spring burning on diets and performance of yearling steers grazing native bluestem range. M.S. Thesis. Kansas State University, Manhattan, Kansas.

Woolfolk, J.S., E.F. Smith, R.R. Schalles, B.E. Brent, L.E. Harbers and C.E. Owensby. 1975. Effects of nitrogen fertilization and late-spring burning of bluestem range on diet and performance of steers. J. Range Manage. 8:163.

Table 1. Intake of salt, mineral and soybean meal (grams per cow daily).

	November 14- May 7		May 8- July 31		August 1- October 31	
	Salt & mineral	Salt	Salt & mineral	Salt	Salt & mineral	Salt
Salt	9	94	17	56	9	34
Soybean meal	101	101	---	---	---	---
Potassium chloride	85	---	---	---	---	---
Dicalcium phosphate	77	---	67	---	26	---
Trace mineral mix[1]	4	---	5	---	2	---

[1] The trace mineral mix included 10% maganese, 10% iron, 14% calcium, 1% copper, 5% zinc, 0.3% iodine, 0.1% cobalt.

Table 2. Least square means for per cent recovery of chromium.[1]

Month	N	Total collections[2]	N	Grab samples[3]
November	6	115.1 $\pm$ 9.2	5	108.8[a] $\pm$ 9.1
December	6	90.3 $\pm$ 9.2	6	121.5[a] $\pm$ 8.2
March	6	88.0 $\pm$ 9.2	6	122.3[a] $\pm$ 8.2
April	6	112.4 $\pm$ 9.3	6	101.2[ab] $\pm$ 8.3
May	7	94.6 $\pm$ 8.5	7	85.4[b] $\pm$ 7.6
June	8	104.0 $\pm$ 7.9	8	117.2[a] $\pm$ 7.0
July	6	93.4 $\pm$ 9.2	6	128.2[a] $\pm$ 8.2
August	8	92.0 $\pm$ 7.9	6	125.9[a] $\pm$ 8.3
September	7	109.1 $\pm$ 8.5	7	123.4[a] $\pm$ 7.6
October	5	105.8 $\pm$10.2	5	129.3[a] $\pm$ 9.1
Mean	65	100.2 $\pm$ 2.8	62	116.5 $\pm$ 2.5

1 The statistical model included month and individual.

2 grams chromium administered per day ÷ grams of chromium in total collections for 24 hours.

3 % chromium in grab samples ÷ % chromium in total fecal collections.

Table 3. Least square means for daily forage intake per cow (kg) by winter supplement and mineral treatment.[1]

Month	Winter Supplement				Mineral Treatment			
	N	Begun Nov. 1	N	Begun Feb. 1	N	Salt + mineral	N	Salt
November	21	8.18 ± .57	23	8.11 ± .54	22	8.34 ± .55	22	7.94 ± .56
December	22	9.25 ± .56	22	9.85 ± .55	22	9.75 ± .55	22	9.35 ± .56
March	15	8.69 ± .71	15	8.16 ± .67	17	7.78 ± .63	13	9.07 ± .74
April	16	11.57 ± .66	17	12.86 ± .63	15	12.48 ± .67	18	11.96 ± .61
May	18	13.61 ± .62	19	12.83 ± .59	17	13.55 ± .63	20	12.89 ± .59
June	17	16.84 ± .64	16	16.91 ± .66	14	17.70 ± .70	19	16.06 ± .60
July	17	9.71 ± .64	17	10.07 ± .63	17	10.42 ± .63	17	9.36 ± .63
August	17	9.59 ± .64	19	9.40 ± .60	17	10.15 ± .63	19	8.84 ± .61
September	18	9.08 ± .62	19	9.25 ± .60	20	9.20 ± .59	20	9.20 ± .59
October	18	10.41 ± .62	19	9.53 ± .60	17	9.93 ± .63	20	10.01 ± .59
Mean	179	10.69 ± .24	186	10.70 ± .20	175	10.92 ± .22	190	10.47 ± .22

[1] The statistical model included month, winter supplement, mineral treatment, month X winter supplement, month X mineral treatment, month X winter supplement X mineral treatment, November weight and age.

Table 4. Least square means for daily forage intake per cow, forage crude protein and digestibility by month.

Month	N	Monthly cow weight, kg[1]	Forage dry matter intake			Percent[4] crude protein	Forage[4] IVDMD(%)
			Kg[2]	Kg/100 kg Nov wt.[3]	g/Nov. Wt.$^{.75}$[3]		
November	44	483	8.12 ± .40^{a}	1.70 ± .08^{a}	78.99 ± 3.77^{a}	6.80	44.04
December	44	473	9.56 ± .40^{bc}	2.00 ± .08^{b}	92.93 ± 3.76^{b}	6.28	48.30
March	30	483	8.26 ± .47^{ab}	1.70 ± .10^{a}	79.49 ± 4.52^{a}	4.78	38.79
April	33	370	12.23 ± .46^{d}	2.54 ± .09^{c}	118.38 ± 4.37^{c}	10.53	47.54
May	37	374	13.30 ± .43^{e}	2.73 ± .09^{c}	127.81 ± 4.13^{c}	15.23	61.26
June	33	408	16.83 ± .46^{f}	3.45 ± .09^{d}	161.78 ± 4.37^{d}	12.73	64.74
July	34	435	9.87 ± .45^{c}	2.05 ± .09^{b}	95.72 ± 4.30^{b}	10.19	41.04
August	36	463	9.42 ± .44^{bc}	1.94 ± .09^{ab}	90.67 ± 4.19^{ab}	8.26	35.74
September	37	467	9.17 ± .43^{abc}	1.90 ± .09^{ab}	88.60 ± 4.13^{ab}	8.16	42.89
October	37	455	9.92 ± .43^{c}	2.04 ± .09^{b}	95.56 ± 4.13^{b}	8.67	46.70

[1] Only weights of cows included in that month's forage intake. The statistical model included month, mineral treatment, pasture within mineral treatment and age.

[2] The statistical model included month, mineral treatment, pasture within mineral treatment, age, and November weight.

[3] The statistical model included month, mineral treatment, pasture within mineral treatment, and age.

[4] From esophageal samples (Pieschel, 1980).

[a,b,c,d,e,f] Means in a column with different superscripts differ significantly (P .05).

Table 5. Least square means for daily forage intake per cow by age.

Age	N	November weight, kg	Forage dry matter intake: Kg[1]	Kg/100 kg. Nov. wt.[2]	g/Nov. wt.$^{.75}$[2]
3	23	402	$9.96 \pm .57^{b}$	$2.19 \pm .11^{bc}$	99.77 ± 5.29^{b}
4 - 5	45	411	$11.80 \pm .42^{a}$	$2.50 \pm .08^{a}$	115.59 ± 3.83^{a}
6 - 7	93	484	$10.33 \pm .29^{b}$	$2.01 \pm .06^{c}$	96.54 ± 2.56^{b}
8 - 9	105	453	$10.42 \pm .25^{b}$	$2.11 \pm .05^{bc}$	99.43 ± 2.41^{b}
10 - 12	99	434	$10.84 \pm .26^{b}$	$2.20 \pm .05^{b}$	103.65 ± 2.47^{b}

[1] The statistical model included month, mineral treatment, pasture within mineral treatment, November weight and age.

[2] The statistical model included month, mineral treatment, pasture within mineral treatment, and age.

[a,b,c] Means in the same column with different superscripts differ significantly (P .05).

Table 6. Least square means for cow weight change and weight-height ratio by winter supplement and mineral treatment.

	Winter supplement		Mineral treatment	
	Begun Nov. 1	Begun Feb. 15	Salt & mineral	Salt
Number of observations	24	25	17	32
November 2, 1977 weight, kg	497	496	505	488
Weight change, kg				
Winter (November 2 to May 4)	-109	-114	-120[a]	-104[b]
Summer (May 4 to November 3)	+ 85	+ 90	+ 85	+ 90
November 3, 1978, weight, kg	472	473	470	475
Weight change, kg				
November 2 to February 2	- 28[a]	- 50[b]	- 48[a]	- 30[b]
February 2 to February 28	- 14[a]	+ 2[b]	- 1[a]	- 10[b]
February 28 to June 1	- 39	- 40	- 44	- 35
Weight-height ratio (Kg/cm)				
November 2, 1977	4.18	4.18	4.22	4.14
February 2	3.95[a]	3.76[b]	3.81	3.89
February 28	3.83	3.78	3.80	3.81

	Winter supplement		Mineral treatment	
	Begun Nov. 1	Begun Feb. 15	Salt & mineral	Salt
June 1	3.50	3.44	3.43	3.51
November 3, 1978	3.98	4.00	3.93	4.03

[1] The statistical model included winter supplement, mineral treatment, winter supplement X mineral treatment, age and whether or not used to determine forage intake.

[a,b] Within winter supplement or mineral treatment, means on the same line with different superscripts differ significantly (P .05).

Table 7. Least square means for reproduction and calf performance.

	Winter Supplement				Mineral treatment			
	N	Begun Nov. 1	N	Begun Feb. 15	N	salt + mineral	N	Salt
Calf birth weight, kg[1]	35	33	28	34	23	34	40	33
Weaning weight, kg[2]	22	182	26	177	13	184	35	174
Percent conception	31	97	32	97	20	90	43	100
Calving interval, days[3]	24	363	29	363	15	361	38	365

[1] The statistical model included winter supplement, mineral treatment, winter supplement X mineral treatment, cow age, calf sex and whether or not cow was used to determine forage intake.

[2] The statistical model included winter supplement, mineral treatment, winter supplement X mineral treatment, cow age, calf sex and whether or not cow was used to determine forage intake.

[3] The statistical model included winter supplement, mineral treatment, winter supplement X mineral treatment, cow age and whether or not cow was used to determine forage intake.

Table 8. Least square means for cow weight change and weight-height ratio by winter supplement X mineral treatment interactions.[1]

Winter supplement	Begun November 1		Begun February 1		
Mineral treatment	Salt & mineral	Salt	Salt & mineral	Salt	Prob. of an interaction
Number of observations	9	15	8	17	
November 2, 1977 cow weight, kg	504	489	505	487	
Weight change, kg					
Winter (November 2 to May 4)	-111	-108	-128	-100	.08
Summer (May 4 to November 3)	+ 80	+ 89	+ 90	+ 91	.52
November 3, 1978 cow weight, kg	474	471	466	478	
Weight change, kg					
November 2 to February 2	- 32	- 24	- 65	- 36	.05
February 2 to February 28	- 13	- 14	+ 11	- 6	.01
February 28 to June 1	- 40	- 38	- 48	- 31	.09
Weight-height ratio (kg/cm)					
November 2, 1977	4.33	4.25	4.28	4.18	
February 2	4.05	4.07	3.72	3.88	.55
February 28	3.92	3.94	3.79	3.82	.88

Winter supplement	Begun November 1		Begun February 1		
Mineral treatment	Salt & mineral	Salt	Salt & mineral	Salt	Prob. of an interaction
June 1	3.63	3.63	3.42	3.57	.56
November 3, 1978	4.08	4.11	3.95	4.11	.62

[1] The statistical model included winter supplement, mineral treatment, winter supplement X mineral treatment, age and whether or not used to measure forage intake.

APPENDIX

FORAGE INTAKE AND PERFORMANCE OF RANGE COWS AS AFFECTED BY DELAYED WINTER SUPPLEMENTAL FEEDING AND MINERAL SUPPLEMENTATION

by

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Seventy-three spring calving Polled Hereford cows grazing native Flint Hills pasture were used to determine monthly forage intake and performance as affected by delayed winter supplemental feeding and year round mineral supplementation. Cows in three pastures were fed 1.4 kg alfalfa hay per cow daily from November 1 to April 6 with an additional 2.7 kg sorghum grain per cow daily from February 15 to April 6. Cows in three other pastures on delayed feeding were fed 1.4 kg alfalfa hay and 2.7 kg sorghum grain per cow daily from February 1 to April 6. One pasture of each supplemental group was fed a salt-mineral mixture balanced for sodium, phosphorous, potassium and copper deficiencies in the grazed forage. The other pastures received salt ad libitum.

Fifty-two cows were used to measure forage dry matter intake in November and December and monthly from March through October. The excretion-to-indigestibility ratio was used with chromium oxide as an external marker and in vitro dry matter digestibility of the grazed forage. Correction factors for incomplete recovery of chromium due to sampling time were determined by dividing the chromium concentrations in the fecal grab samples of 4 steers by the concentration in total fecal collections from the same steers.

Forage intake was not influenced by winter supplement, but those cows receiving minerals consumed slightly more (P=.11) forage (10.92 vs. 10.47). Forage intake was influenced by month (P .001), pasture within mineral treatment (P .01) and age of cow (P=.02). Least square means for daily forage intake per cow by month were 8.12, 9.56, 8.26, 12.23, 13.30, 16.83, 9.87, 9.42, 9.17, and 9.92 kg dry matter per cow daily. This represents 1.70, 2.00, 1.70, 2.54, 2.73, 3.45, 2.05, 1.94, 1.90 and 2.04 percent of fall body weight respectively. Daily forage dry matter intake by per cow age are 9.96, 11.80, 10.33, 10.42 and 10.84 kg dry matter per cow daily for 3, 4-5, 6-7, 8-9 and 10-12 year olds respectively. Forage intake increased (P .01) linearly as beginning November weight increased (b=.00974) and was not influenced by level of milk production.

Cows not supplemented until February lost more (P .01) weight from November to February and had a lower weight-height ratio one month prior (February 2) to the beginning of the calving season. Weight gains during February were greater (P .001) for cows on delayed supplemental feeding. Weight-height ratio at the beginning of the calving season, weight loss from calving to breeding and total winter weight loss were similar for both groups. Birth weights, weaning weights and reproductive performance were similar. Providing a salt-mineral mixture did not improve reproduction, calf performance or summer weight gain. Winter weight loss was increased when minerals were fed (P=.05).