Forage intake of Hereford and 75% Simmental-25% Hereford cows grazing Montana foothill rangeland

by Scott Lloyd Kronberg

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Range Science
Montana State University

Abstract:
Forage intake was estimated for Hereford and 75% Simmental-25% Hereford cows grazing in north central Montana during the summer. The cows ranged freely over a 8lha (200ac) pasture of foothill rangeland. Intake was estimated for 4 dry cows of each breed type in 1981 and 6 dry and 6 lactating cows of each breed type in 1982. The fecal output of dry cows was measured with total fecal collections and estimated with the chromic oxide dilution technique. Only the chromic oxide technique was used for lactating cows. Three to 4 esophageal fistulated cows of each breed type were used for collection of dietary material suitable for typical in vitro digestibility laboratory analysis. The average body weight of the dry Hereford cows was 440kg in 1981 and 553kg in 1982. The average body weight of the dry crossbred cows was 607kg in 1981 and 638kg in 1982. The average body weights of lactating Hereford and crossbred cows were 460 and 572kg, respectively. Forage intake estimates were expressed as a percent of body weight/day (OMB). Estimates of forage intake for the larger crossbred cows were compared to estimates obtained for the smaller Hereford cows. Intake estimates reported here were determined using the chromic oxide derived fecal output estimates. Estimates of dry Hereford intake were 1.1 and 1.3 for 1981 and 1982, respectively. The intake of dry crossbreds was estimated at 0.9 and 1.3 for 1981 ana 1982, respectively. Intake of dry Hereford and crossbred cows was not different ($P>.10$), but the lactating crossbred cows consume more ($P<.10$) forage (2.1) than the lactating Hereford cows (1.9). With metabolizable energy of the range forage estimated at 1.8 Mcal/kg (0MB), ME consumption was estimated at 15.6 and 21.6 Mcal/day for the lactating Hereford and crossbred cows, respectively.

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A thesis submitted in partial fulfillment
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of

Master of Science

in

Range Science

MONTANA STATE UNIVERSITY
Bozeman, Montana

December 1983

APPROVAL

of a thesis submitted by

Scott Lloyd Kronberg

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Acknowledgements

There were many people who were involved in this project and I feel that in many ways it was a team effort. I thank my friends Chuck Steffan and Mark Turner for their help with the seemingly endless hours of catching cows and cleaning fecal bags. I thank my friend Eldon Ayers for the same reasons. I also thank him for his advice, criticism and instruction. I learned much from Eldon.

For their instruction and assistance with my laboratory analysis I thank Collene Weinzetl, Gayle Watts, Nancy Roth and Chris Lahaye. Their support is sincerely appreciated.

I thank Jeanne Blee for typing portions of my thesis and for teaching me how to use the word processing system.

I thank Dr. Don Kress, Dan Doornbos and Don Anderson for providing the cows and facilities for the fieldwork for this study. I thank Charlotte and Webster Thackery for their genorous hospitality and support during the two summers of fieldwork.

I also thank my graduate committee, Drs. Maurice Hull, Clayton Marlow and Brian Sindelar for their patience and support.

Finally, I would like to thank my friend and advisor Dr. Kris Havstad for his patience and guidance and for the countless hours that he worked with me in the Bearpaws.

I'll never forget the comradery that Kris, Eldon, Mark and I shared in the Bearpaws.

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

Forage intake was estimated for Hereford and 75% Simmental-25% Hereford cows grazing in north central Montana during the summer. The cows ranged freely over a 81ha (200ac) pasture of foothill rangeland. Intake was estimated for 4 dry cows of each breed type in 1981 and 6 dry and 6 lactating cows of each breed type in 1982. The fecal output of dry cows was measured with total fecal collections and estimated with the chromic oxide dilution technique. Only the chromic oxide technique was used for lactating cows. Three to 4 esophageal fistulated cows of each breed type were used for collection of dietary material suitable for typical *in vitro* digestibility laboratory analysis. The average body weight of the dry Hereford cows was 440kg in 1981 and 553kg in 1982. The average body weight of the dry crossbred cows was 607kg in 1981 and 638kg in 1982. The average body weights of lactating Hereford and crossbred cows were 460 and 572kg, respectively. Forage intake estimates were expressed as a percent of body weight/day (OMB). Estimates of forage intake for the larger crossbred cows were compared to estimates obtained for the smaller Hereford cows. Intake estimates reported here were determined using the chromic oxide derived fecal output estimates. Estimates of dry Hereford intake were 1.1 and 1.3 for 1981 and 1982, respectively. The intake of dry crossbreds was estimated at 0.9 and 1.3 for 1981 and 1982, respectively. Intake of dry Hereford and crossbred cows was not different ($P>.10$), but the lactating crossbred cows consume more ($P<.10$) forage (2.1) than the lactating Hereford cows (1.9). With metabolizable energy of the range forage estimated at 1.8 Mcal/kg (OMB), ME consumption was estimated at 15.6 and 21.6 Mcal/day for the lactating Hereford and crossbred cows, respectively.

INTRODUCTION

There are 262 million hectares of rangeland in the western and Great Plains states. Of these, approximately 89% are grazed by livestock (USDA, 1974). These animals interact in range ecosystems in numerous ways, but their intake of vegetation is a primary interaction and one of great importance to range managers. Range managers interested in producing livestock and maintaining vigorous forage production must know how much forage their livestock eat and how much forage their range produces in order to determine the carrying capacity of their land. The quantity of vegetation consumed by an herbivore depends on the nutritional requirements of that animal and the quantity and quality of forage available to it (Bines, 1971). Its nutritional requirements are determined by its metabolic rate, growth and reproductive status and its energy expenditures relative to the environment it exists in (i.e. thermoregulation and travel for forage, minerals and water) (Cook, 1970).

Forage intake estimates have been made for many domestic and wild ruminants with varying nutritional requirements, but only a few of these estimates have been made for one of the most common ruminants grazing U.S. rangelands - the lactating beef cow (Van Dyne et al., 1980). There are many different breed types of cows grazing U.S. rangelands. These cows vary in nutritional requirements due to differences in body size, age, reproductive and lactation status, environments and behavior (Cook, 1970). Little research has been conducted which provides a basis to compare the forage consumption of lactating cows with different nutritional requirements and which provides insight into which differences, among cows of different breed types, are most accountable for differences in forage intake.

With rapidly increasing costs and reduced profits in beef production, and with the cow herd consuming about 60% of feed required for beef production (Ferrell and Jenkins, 1982), cattle producers are becoming increasingly concerned with the productive efficiency of their cow herds. At the same time many cattlemen are striving to produce calves with heavier weaning weights. To do this, some producers are turning to the larger European breeds of cattle to introduce traits into their cow herd which will result in the production of heavier calves. When the crossbred progeny of European and British breeds are used in a commercial herd, their calves are typically larger than calves of straightbred Hereford or Angus cows (Steffan, 1983). The first impression is that these larger calves increase profits for livestock producers, but several factors must be considered before this conclusion can be accurately made. Production factors related to the pounds of calf produced in a cow's lifetime, growth of calves after weaning and carcass value of the finished calves are all important factors for consideration. Maintenance costs of the cow must then be weighed against her productive ability to determine her productive efficiency. The maintenance cost of the cow include health care, livestock facilities and the forage she consumes. Livestock facility cost are reasonably uniform for cows of different breed types, but the costs for health care and forage must be assessed to determine the maintenance costs for a cow of a particular breed type.

For the past 6 years, animal scientists associated with Montana's Northern Agricultural Research Center have been comparing the productivities of Hereford and Simmental-Hereford cows. Their research is gathering information with which they can compare the productivities of different breed types of cows, the rate of gain of calves in feedlot and calf carcass value. Their research has not investigated forage intake of the grazing cows, so they could not compare the productive efficiencies among cows of different breeding.

This study had two objectives. The first was to estimate and measure fecal output of dry Hereford and 75% Simmental- 25% Hereford cows. Accuracy of the chromic oxide indicator technique for estimating fecal output could then be assessed. The second objective was to estimate the forage intake of dry and lactating Hereford and 75% Simmental- 25% Hereford cows. With this information, comparisons of intake could be made among the two breeds of cows and among dry and lactating cows. This information could also be combined with cow production records to estimate productive efficiencies of the Hereford and 75% Simmental-25% Hereford cows.

LITERATURE REVIEW

Introduction

Of the various nutrients required by cattle and available in the water-less portion of forage (energy supplying compounds, proteins, vitamins, and minerals), the energy supplying compounds are the nutrients required in the largest amounts (Knox, 1967). Mature cows, nursing calves, require energy for maintenance, lactation and reproduction. Immature cows require additional energy for growth. Estimates of daily metabolic energy needs for maintenance and lactation vary from 15.9 to 27.5 Mcal depending on the cow's weight and quantity of milk production (NRC, 1976). Free-roaming lactating cows require additional energy for grazing, travel, thermoregulation and possibly for the extra work of handling bulky forage (Osuji, 1974). Havstad (1981) observed a 45% increase in energy expenditures of free-roaming heifers compared to that of their housed counterparts. He attributed 50% of this additional energy cost to grazing and 20% to travel. Young (1970) and Wallace (1956) found free-roaming energy expenditures, for cattle, to be 60 and 50% above energy expenditures for maintenance. Assuming a 50% increase in energy expenditures for free-roaming cows, and using the estimates for daily metabolic energy needs previously mentioned, metabolic energy requirements for free-roaming lactating cows may be as high as 23.9 to 41.3 Mcal/day.

There is considerable evidence that animals generally attempt to match their energy intake with their energy expenditures (McClymont, 1967; Blaxter, 1962; Bines, 1971; Baile and Forbes, 1974).

With the metablic energy content of western foothill grasses averaging 2.2Mcal/kg on an organic matter basis (OMB) (NCR, 1976), a free-roaming lactating cow would have to consume about 10.9 to 18.8 kg of forage/day, depending of her particular requirements, to meet her energy needs.

Regulation of Forage Intake

The fact that ruminants fed a diet of medium to high caloric density stop eating before filling their reticulo-rumen suggests that one or more physiological processes exist which regulate their food intake (Bines, 1971). Meijs (1981) suggested 3 types of mechanisms of metabolic control: chemostatic, thermostatic and lipostatic and several factors related to physical control that may regulate food intake. Forbes (1979) proposed that a combination of factors are likely responsible for intake regulation. Van Soest (1982) submitted that research which clearly demonstrates a single mechanism responsible for intake regulation does not exist.

For ruminants on highly digestible diets without heat, cold or nutrition stress, phagic behavior is believed to be controlled primarily by levels of available energy substrates (volatile fatty acids) in the body (Baile and Forbes, 1974; Meijs, 1981). Baile and Mayer (1968) and Bines (1971) suggested that receptors sensitive to volatile fatty acids may occur on the lumen side of the rumen wall and in the veins draining the rumen. Forbes (1979) proposed that the receptors sensitive to the volatile fatty acid propionate may occur in the liver. Neural or hormonal signals from these receptors are believed to integrate in the hypothalamus where a satiety control center is believed to exist (Van Soest, 1982). This chemostatic model proposes that intake is initiated when energy requirements exceed energy available in the body, minus a lower threshold, and stops when energy available exceeds energy requirements (Anil and Forbes, 1977). Balch and Campling (1962) and Montgomery and Baumgardt (1965) have proposed that there may be thermostatic mechanisms controlling food intake. This theory is based on the existence of temperature sensitive centers in the hypothalamus which may respond to changes in body temperature due to heat produced during nutrient metabolism (Jones, 1972; Meijs, 1981). Experiments designed to test this theory have generally been unable to show that thermostatic regulation of intake operates under normal physiological conditions (Balch and Campling, 1962; Jones, 1972). However, changes in environmental temperature does appear to affect food intake (Jones, 1972; Rohr, 1977, as cited by Meijs, 1981). Baile and Forbes (1974) and Bines (1971) determined that food intake of ruminants increased in a cold environment and decreased in a warm or hot environment. Malechek and Smith (1976) found that under extreemly cold conditions, cattle reduced grazing time.

Finally, ruminant food intake may be partially controlled by lipostatic mechanisms (Balch and Campling, 1962). Meijs (1981) suggested that animals strive to maintain a particular condition by eating when they are too thin and trying to build-up some fat reserves when possible. Journet and Remond (1976) have proposed that free fatty acids may directly affect the intake control center in the hypothalamus. Baumgardt (1970) has proposed that the size of the adipose cells may provide signals to the hyothalamus while Baumgardt (1970) and Baile and Forbes (1974) suggested that there may be a hormonal control linking centers of fat accumulation to tne hypothalamus. No clear evidence has been found for any one of these theories (Meijs, 1981). Bines et al (1969) demonstrated that intake of concentrates is reduced in fat ruminants before the rumen is filled to capacity. This suggests that a lipostatic control may at least partially account for regulation of intake. Fat accumulations around the gut reduce the ability of these organs to expand within the abdominal cavity and thus act indirectly to limit the quantity of digesta that these organs can hold (Campling, 1970; Forbes, 1970).

In addition to the metabolic processes thought to regulate intake, there is considerable evidence that limitations of reticulo-rumen capacity can affect food intake in ruminants (Balch and Campling, 1962; Baile and Forbes, 1974). Campling (1970) found that additions of food into the reticulo-rumen, through a fistula, caused an immediate decrease in eating while removal of food from the rumen caused the animal to eat much longer than normal. Grovum (1979) found that when the reticulums of sheep were distended with water-filled balloons their food intake was depressed. When the balloons were removed, the animal resumed feeding. Conrad et al. (1964) determined the food intake of lactating dairy cows. The dry matter digestibility of the rations ranged between 52 and 80% and the cow weights varied between 283 and 661kg. They concluded that physical and physiological factors regulating food intake change in importance with increasing digestibility of the diet. With low digestibilities, body weight (reflecting reticulo-rumen capacity), passage rate of digesta and digestibility of diet appear to regulate intake. At high digestibilities, intake appeared to be regulated by metabolism, production and diet digestibility. Nutt et al. (1980) found that among cows grazing low quality pasture (average dry matter digestibility of 55%), a positive relationship existed between rumen capacity and forage intake. For cows grazing high quality pasture (average dry matter digestibility of 60%), they found no relationship between these two factors. From their results they also hypothesized that forage intake was regulated by different factors for cows grazing high and low quality pasture. Blaxter et al. (1961) showed a strong positive association between the apparent digestibility of roughages and the amount consumed by sheep. Further research has demonstrated that movement of digesta through the alimentary canal is limited by passage of digesta particles through the reticulo-rumen orifice into the omasum (Balch and Campling, 1962). Particles must be of a small size to pass out of the rumen (Balch and Campling, 1962). Particles are reduced in size primarily by chewing, during mastication and rumination, digestive action of microbial fermentation in the reticulo-rumen and muscular action of the gut (Balch and Campling, 1962). The rate at which microbial fermentation occurs depends on what type and number of microorganisms exist in the reticulo-rumen (Van Soest, 1982). The number and type of rumen microbes is related to the chemical content of the ingesta (Bines, 1971). Diets with adequate protein levels usually have higher bacterial numbers than those with diets low in protein (Church, 1976). Diets that are richer in readily fermentable nutrients (higher digestibility and protein content) support greater numbers of microbes (Warner, 1965; Giesecke et al., 1966). Thorley et al. (1968) found substantial differences in bacterial species composition from cows when isolated cultures were fed different rations and Pietraszek and Maluszynska (1970, as cited in Church, 1976) found substantial differences in isolated bacterial compositions of sheep when fed either alfalfa or meadow hay. The limitations of the reticulo-rumen to process lower quality forage has important implications on forage intake of range cattle. Range forage is often of low to medium digestibility and protein content through much of the year (Kartchner and Campbell, 1979; Kothmann, 1980; Van Dyne et al., 1980). Conrad et al. (1964) studied the feed intake rate of lactating cows fed diets varying from 50 to 80% dry matter digestibility. He concluded that cows fed rations of 67% or greater digestibility could increase or decrease intake to meet their energy needs while cows fed rations of less than 67% dry matter digestibility had intakes limited by their physical capacity to process food. Montgomery and Baumgardt (1965) pointed out that diet digestibility should not be used alone as the criteria on which to base the "critical point" for control of intake. Factors such as physical form of ingesta, energy and protein concentrations and passage rates must also be taken into account.

Factors Affecting Forage Intake

In Meijs's (1981) thorough review of the factors affecting forage intake of grazing animals, he suggested that these factors can be divided in 3 groups: factors related directly to the animal, factors related directly to the forage resource and factors related to the management of the animal and forage resource. Meijs acknowledged that these factors are interrelated.

The primary factors related to the animal are: age, weight, pregnancy status, lactation status and condition (Meijs, 1981). Young animals require additional nutrients for growth. Energy supplying compounds are the nutrients required in greatest additional amounts followed by proteins and various minerals and vitamins (Maynard et al., 1979). A 2-year old heifer, with a daily growth rate of 0.33 kg/day, would require approximately 3,450 Kcal of metabolic energy to satisfy her energy requirements for growth (Havstad, 1982). To meet this metabolic energy need, she would have to consume about 1.6 kg of forage in addition to the forage she consumed to meet her other energy needs.

Heavier animals generally consume greater quantities of forage than lighter animals (Van Soest, 1982). Hyppola and Hasunen (1970, as cited by Bines, 1976) found a correlation of 0.79 between roughage dry matter intake and the live weight of dairy cows. Van Soest (1982) suggested that ruminant gastrointestinal capacity is directly related to body size. Therefore, a larger animal would have the ability to consume greater quantities of forage before reaching its reticulo-rumen capacity, when forage quality is the primary factor regulating intake. Conrad et al. (1964) found that the intake of lactating cows varied in direct proportion to body weight when the diet dry matter digestibility was below 66%.

Changes in forage intake have been clearly documented for pregnant ruminants (Campling, 1966; Forbes 1970; Bines 1971). Penzhorn and Meintzes (1972) and Bines (1976) observed increases in food intake of pregnant non-lactating heifers. They attributed part of this increase to pregnancy and part to growth. Meijs (1981) suggested that the affect of early and mid-pregnancy on the forage intake of cows in not well understood. Campling (1966), Johnson et al. (1966) and Curren et al. (1967) have demonstrated that cows in their last 6 weeks of pregnancy reduce their roughage intake by 12 to 15%. This is generally believed to be associated with the reduction in rumen capacity due to fetal growth (Meijs, 1981), but Forbes (1970) suggested that the reduced intake may be partly due to hormonal changes related to pregnancy.

Increased consumption of food by lactating cows is well documented (Hutton, 1963; Campling 1966). The records of Elliot et al. (1961) show a 25 and 32% increase in organic matter intake of lactating Afrikander and Mashona cows, respectively, over that of their dry counterparts. Field (1966) observed a 25% increase in dry matter intake of lactating cows over that of their non-lactating identical twins, while Jones et al. (1965) noted a 35% increase in organic matter intake. This significant increase in intake is provided for by the hypertrophy of the alimentary tract which occurs in lactating cows (Leaver et al., 1969; Smith and Baldwin, 1974). Campling (1970) suggested that this hypertrophy arises from endocrine changes associated with the beginning of lactation, but the mechanism is not understood.

Social behavior of ruminants may also affect their forage intake (Arnold, 1970; Jamieson, 1975, as cited by Meijs, 1981). Tribe (1950) observed that when a group of sheep were supplemented with grain, the supplemented sheep grazed longer when they were with the unsupplemented sheep then when they were alone. Holder (1962) conducted similar experiments with sheep, but found that the unsupplemented sheep tended to decrease grazing and intake to match that of the supplemented sheep.

The forage intake of ruminants is also affected by factors associated directly with the forage resource. Arnold and Dudzinski (1967) and Rodriquez and Hodgson (1974) found that the forage related factors most important in explaining variation in forage intake were forage digestibility, forage mass and forage height. The relationship between forage digestibility and intake has already been discussed to some extent in this review. Forage digetibility appears directly related to forage cell wall content (Van Soest, 1965). Van Soest (1965) reported that when cell-wall content is high and the proportion of cell-wall constituents increase, voluntary intake declines. Baker (1975) attributed differences in forage intake between forage species to differences in proportion of cell-wall contents. Corbett et al. (1963) found that a change in forage digestibility from 80 to 68% resulted in a 5% reduction in intake of grazing dairy cows with more of the intake reduction occurring at the lower levels of digestibility. Other experiments designed to look at the relationship between changing forage digestibility and intake have been less conclusive (Meijs, 1981). Studies on the relationship of changes in forage mass, due to maturity, and forage intake are often confounded by changes in forage digestibility or available forage (Meijs, 1981). Stobbs (1973a) suggested that bite size may be a limiting factor on intake at low levels of forage mass. Hodgson (1968) varied forage mass with varying levels of nitrogen fertilization and found that while digestibility of the diet explained 79% of variation in forage intake, forage mass did not significantly affect intake. Alden and Whittaker (1970) found a close association between rate of forage intake of grazing sheep and tiller length, while Stobbs (1973b) demonstrated that forage density is the most important forage factor affecting bite size in tropical pastures, but neither of these studies show a relationship between total forage intake and spatial distribution of the forage resource.

Another forage related factor that may affect intake is mineral content. Kirchgessner and Roth (1972 as cited by Meijs, 1981) found that forage phosphorus content had a significant positive effect on intake of grazing cattle, but sodium calcium and magnesium did not. Ernst (1978 as cited by Meijs, 1981) and Finger and Werk (1973 as cited by Meijs, 1981) found a positive affect of sodium content on forage intake. The affect of mineral content of forage on intake may depend on the particular requirements and deficiencies of an individual or group of animals.

There are a number of factors related to animal and forage management that can influence forage intake. The quantity of forage available to a grazing animal can obviously influence the quantity of forage consumed by the animal, but the level at which forage availability becomes a controlling factor on intake appears to depend on the quantity and quality of the forage. Havstad et al. (1983) reported that intake values for cattle grazing a diminishing supply of crested wheatgrass (digestibility of 33 to 43%) were not significantly different when forage availability decreased from 920 to 140 kg/ha. This study indicates that under conditions where low forage quality limits intake, the quantity of forage available to a grazing animal may not alter daily intake. Handl and Rittenhouse (1972) reported a decline in intake when forage availability dropped below 176 kg/ha (forage digestibility of 66%).

Other factors such as dietary supplementation, nitrogen fertilization, season of use and grazing systems can affect forage intake. Adequate review of these factors is beyond the scope of this literature review, therefore, they are not included.

General Trends

Cordova et al. (1978) reviewed the literature on forage intake of grazing livestock. They reported that most estimates of intake for sheep and cattle, grazing western U.S. ranges, lie between 1 and 2.8% of body weight/day. Van Dyne et al. (1980) extensively reviewed the literature on forage intake of large range herbivores. They reported cattle intake estimates from 51 different studies which used a variety of techniques to estimate forage intake. Forage intake estimates, expressed as a % of body weight/day, ranged from a low of 0.96 for cattle grazing northern desert shrub in winter to a high of 3.2 for calves grazing ryegrass and white clover pasture during the growing season. From the estimates expressed on an organic matter basis

(OMB), they reported averages of 2.4 and 2.1 for spring and summer grazing, respectively. From the estimates expressed on a dry matter basis (DMB), they reported averages of 2.1 for both spring and summer grazing. Forage intake is often expressed on an organic matter basis because of the high ash content of range forage (Cordova et al. 1978). Estimates of forage intake for range cows are much less common than estimates for steers or heifers (Van Dyne, 1980; Cordova et al., 1978). Table 6 in Appendix B presents some estimates of forage intake for free-roaming cows compiled from the literature.

DESCRIPTION OF STUDY SITE

The study pasture was located at 1219-1341m (4000-4400ft.) on the northwestern slopes of the Bearpaw mountains in north central Montana. The pasture was approximately 81 hectares (200 acres) in size and its terrain was rugged with slopes up to 25%. The pasture was predominantly upland with a few small scattered lowland areas. Average annual precipitation is 457-508mm (18-20 inches) (USDA-SCS, 1976). The Soil Conservation Service (USDA-SCS, 1976) classified the area as a silty range site with potential climax vegetation primarily dominated by rough fescue (*Festuca scabrella* Torr.), Idaho fescue (*Festuca idahoensis* Elmer) and bluebunch wheatgrass (*Agropyron spicatum* [Pursh] Scribn. & Smith). Mueggler and Stewart (1980) suggested that the rough fescue-Idaho fescue habitat type is potentially one of the most productive upland forage types for cattle in Montana. They found that a relatively undisturbed area of this habitat type produces at least 1,120 kg/ha (1000 lbs/acre) of air-dry vegetation which is mostly palatable grasses. Typically, the biomass of these areas is 30-85% rough fescue with 70-80% of the total biomass composed of graminoids. Rough fescue is considered to be very palatable to cattle and declines under heavy grazing (Mueggler and Stewart, 1980). Both Mueggler and Stewart (1980) and the SCS (1976) suggested that Idaho fescue usually increases under heavy grazing in this habitat type. Other species which increase under heavy grazing of this habitat type are: prairie junegrass (*Koelaria pyramidata* [Lam.] Beauv.), threadleaf sedge (*Carex filifolia* Nutt.), prairiesmoke

(*Geum triflorum* Pursh), danthonia (*Danthonia* spp.), Kentucky bluegrass (*Poa pratensis* L.), shrubby cinquefoil (*Potentilla fruticosa* L.), lupine (*Lupinus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata* [Pursh] Nutt.), pussytoes (*Antennaria* spp.), western yarrow (*Achillea millefolium* L.) Sandberg bluegrass (*Poa sandbergii* Vasey) and various annuals (Mueggler and Stewart, 1980) and (USDA, 1976).

The majority of the study pasture was grassland, but a small portion of the pasture had a ponderosa pine (*Pinus ponderosa* Laws) overstory. The ponderosa pine was not considered in species composition estimates because it was not considered a potential forage species for cattle. Species composition was based on canopy cover. Rough fescue and Idaho fescue composed an average of 15% and 10% of the upland vegetation, respectively. Bluebunch wheatgrass, thickspike wheatgrass (*Agropyron dasystachyum* (Hook.) Scribn.), needleandthread (*Stipa comata* Trin. & Rupr.), and threadleaf sedge accounted for an average of 2, 8, 5 and 14% of the upland vegetation, respectively. Together these graminoid species composed an average of 54% of the upland vegetation. The forb species lupine, prairiesmoke and Hood's phlox (*Phlox hoodii* Rich.), composed an average of 16, 5 and 5% of the vegetation, respectively. Miscellaneous grass and forb species accounted for the remaining 11% of the vegetation.

Kentucky bluegrass dominated the lowland vegetation. An average of 71% of the lowland vegetation was composed of this species. Western wheatgrass (*Agropyron smithii* Rydb.), Idaho fescue, green needlegrass (*Stipa viridula* Trin.), and needleleaf sedge (*Carex eleocharis* (Bailey) Hulten), accounted for an average of 3, 1, 1 and

1% of the lowland vegetative composition. Western snowberry (Symphoricarpos occidentalis Hook.), and prairie rose (Rosa arkansana Porter), accounted for a mean of 7 and 3% of the lowland composition while lupine, sticky geranium (Geranium viscosissimum Fisch. & Mey.) prairiesmoke and hairy goldenaster (Heterotheca villosa (Pursh) Shinners) made up 5, 4, 2 and 1% of lowland vegetative composition. A list of plant species occurring in the study pasture is presented in Appendix A. Table 7 in Appendix B presents information on canopy cover and composition of prominent species in the pasture.

Using the SCS procedure for range condition rating and biomass data collected from representative areas of the study pasture, upland areas were rated in exellent range condition. Although lowland areas produced a significant quantity of forage relative to their size, range condition was rated poor for these areas due to the preponderance of the invader species Kentucky bluegrass.

Soils of the study pasture are moderately deep Haploborolls on slopes and lowlands and shallow Lithic Haploborolls on ridge tops (Montagne et al., 1982). Average frost free season is ninety days (Caprio, 1965). Average date of last spring freeze is June fourth while the average date of first freeze is September second (Caprio, 1965). The typical grazing season in the area begins in May and ends in November to December depending on forage availability and snow depth.

Several plants poisonous to cattle occurred in the study pasture. Two-grooved milk vetch (Astragulus bisulcatus (Hook.)) occurred in the study pasture, but did not appear to be grazed. Chokecherry (Prunus *virginiana* L.) also occurred infrequently, but the cows only ate it in very small quantities if they ate it at all. Green ponderosa pine needles were available but the cows did not appear to be consuming them. No cows were observed suffering from poisoning during the two summers of the study.

METHODOLOGY

Experimental Design

The experiment had a randomized complete block design. Forage intake estimates were determined on randomly selected Hereford and 75% Simmental-25% Hereford cows and blocked by the months of fecal output and forage digestibility estimation.

Intake

Forage intake was estimated using the equation:

$$\text{Organic matter intake} = \frac{\text{Total fecal organic matter output}}{\text{1-dietary organic matter digestibility}} .$$

Organic matter intake was expressed as a % of body weight. Body weights were determined prior to each collection following a 14hr overnight shrink period where all cows were kept off feed and water so as to standardize their pre-weighing feed and water intake levels.

Fecal Output

Total fecal organic matter output was estimated with total fecal collections and the chromic oxide dilution technique (Raleigh et al., 1980). Total fecal collections were made on dry cows for 96 hour periods once per month. Fecal collection bags and feces-urine flaps as described by Kartchner and Rittenhouse (1979) were used. Collections were made in July through Setptember of 1981 and June through September of 1982. Four cows of each breed type were used in 1981 and six cows of each breed type were used in 1982. Cows were gathered twice daily at approximately 12 hour intervals. Fecal collection bags were then removed, weighed, emptied into containers, cleaned, relined with plastic liners, reweighed and reattached to the cow. Contents of each container was then throughly mixed and sampled. The samples were promptly frozen. At a latter date these samples were analyzed for dry matter and organic matter following AOAC (1970) procedures.

Beginning six days prior to the total fecal collection period, each cow was dosed daily, at approximately six pm, with ten grams of chromic oxide powder. The chromic oxide powder was contained in 28 gram (one ounce) gelatin capsules and administered with a balling gun. At the same time, a fecal grab sample was taken from the rectum of each cow, placed in a plastic bag and froze. At a latter date these samples were thawed, dryed in a forced air dryer at 40C, ground through a 1mm screen then analyzed for chromic oxide content. A colorimetric procedure outlined by Bolin et al. (1952) and modified by Newman (1983) was used for chromic oxide analysis. The percent of chromic oxide in a fecal grab sample was entered into the equation:

$$\text{Fecal output/day} = \frac{\text{Quantity of } Cr_2O_3 \text{ fed/day} \times 100}{\% \text{ of } Cr_2O_3 \text{ in grab sample}}$$

to obtain an estimate of daily fecal dry matter production for each cow. Estimates were then converted to an organic matter basis for comparison with fecal output estimates from total fecal collection.

In 1982, fecal output estimates were also determined for six lactating cows of each breed type using the chromic oxide dilution technique. These cows were dosed with chromic oxide and sampled in the same manner as the dry cows. Both dry and lactating cows were pastured and handled together.

Diet Digestibility

Dietary organic matter digestibility was determined on extrusa material using Barne's modification of the Tilley and Terry *in vitro* technique (Harris, 1970). Extrusa samples were collected from cows, of both breed types, equipped with esophageal fistulas. Extrusa collections were made approximately four times/month during the 10 day period of chromic oxide administration. Fistulated cows were penned overnight prior to morning extrusa collections. To obtain extrusa samples, their canulas were removed and extrusa collection bags were attached. The animals grazed unattended for one-half hour before being herded back into the corral where their bags were removed and canulas reinstalled before being released. Extrusa was removed from the collection bag, placed in a plastic bag and froze promptly. At a later date, the extrusa samples were dryed at 40C in a forced air dryer, mixed and a portion of the sample was ground through a 1mm screen. A portion of the ground sample was then used in the *in vitro* digestibility analysis. The rumen fluid used in the *in vitro* procedure was obtained from a mature, stall-fed cow that received a ration of good quality grass hay and had free access to water and a trace mineral salt block.

Statistical Analysis

One factor analysis of variance was used to compare monthly mean fecal output and forage intake estimates between breed types and fecal output estimating techniques. To examine for factors significant in explaining variation in intake, multiple regression analysis was used. The alpha level used for determining significance was 0.10.

RESULTS

Comparison of Fecal Output Estimates

Fecal output estimates, from the two estimating techniques for both breed types, are presented in Table 1. Collections during the 1981 season showed no significant difference in the overall fecal output means, between the two techniques. Both techniques estimated fecal output at 0.7% of body weight/day for Herefords while the total collection and chromic oxide techniques estimated fecal output at 0.6 and 0.5% of body weight/day, respectively for the crossbred cows.

Table 1. Daily fecal output of dry cows as estimated using the total collection and chromic oxide techniques.

	Hereford Cows		Crossbred Cows	
Collection Period	Total Collection Technique	Chromic Oxide Technique	Total Collection Technique	Chromic Oxide Technique
	------------	------------ $\%^{a}$	------------	------------
July, 1981	0.5^{b}	0.6^{b}	0.5^{b}	0.5^{b}
August, 1981	0.7^{b}	0.7^{b}	0.6^{c}	0.6^{c}
September, 1981	0.8^{b}	0.7^{bc}	0.7^{c}	0.5^{d}
1981 overall mean	0.7^{b}	0.7^{b}	0.6^{bc}	0.5^{c}
June, 1982	0.5^{b}	0.7^{c}	0.6^{bc}	0.6^{bc}
July, 1982	0.7^{b}	0.8^{c}	0.6^{b}	0.7^{bc}
August, 1982	0.7^{b}	0.7^{b}	0.7^{b}	0.8^{b}
September, 1982	0.7^{b}	0.8^{c}	0.6^{d}	0.8^{bc}
1982 overall mean	0.7^{b}	0.8^{c}	0.6^{b}	0.7^{c}

[a]Percentage of body weight on an organic matter basis.
[b,c,d]Means within a row with different superscripts differ ($P \leq .10$).

For individual month means, only the crossbred September collection had a significant difference between the two techniques. In contrast, the 1982 overall means for the two techniques were significantly different. For the Hereford cows, the chromic oxide derived estimate of 0.8% of body weight/day is approximately 14% greater than the total collection derived estimate of 0.7% of body weight/day. For the crossbred cows, the chromic oxide derived estimate of 0.7 was nearly 17% larger than the total collection estimate of 0.6.

Forage Digestibility

Mean forage digestibility estimates and their standard deviations are displayed in Table 2. The 1981 values are somewhat lower than the 1982 values and values reported by Kartchner and Campbell (1979) and Cook and Harris (1968). Digestibility may have been reduced in the preparation of the 1981 extrusa samples for the *in vitro* analysis by excessive heat during drying or excessive loss of soluble organic portions of the forage (Acosta and Kothmann, 1978). Because the digestibility values for 1981 were used only to estimate the forage intake of dry cows, their lower than expected nature was not a serious concern of the study.

Table 2. Forage digestibility of diets selected by esophageal fistulated cows.[a]

	June		July		August		September	
Year	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1981	-	-	39	10	34	4	35	13
1982	59	6	45	11	41	16	55	4

[a]Percentage of *in vitro* organic matter digestibility.

The 1982 values approximate expected values quite closely (Cook and Harris, 1968). Forage digestibility was highest in June when forage was young, succulent and low in less digestible cell wall contents. It decreased through July and August as the forage dried and increased in cell wall contents. With considerable late August precipitation and resumed plant growth, forage digestibility increased markedly in September as the cows were again grazing young succulent plant growth.

No significant differences in digestibility exist between extrusa collections for the Hereford and crossbred cows. Consequently, digestibility values for extrusa collections from both breed types are combined to make one value for each collection period.

Forage Intake of Dry Cows

Because the same forage digestibility values were used to determine intake estimates for Hereford and crossbred cows, differences in intake between these two breed types were simply reflections of their fecal output differences. Significant differences between intake estimates from the total collection and chromic oxide techniques were identical to those between fecal output estimates. Mean intake values for both breed types, for all collection periods, are presented in Table 3.

Mean intake estimates, for the three collection periods of 1981, showed significant differences between the two breed types with the chromic oxide technique, but not the total collection technique.

However, mean estimates for the 1981 August and September collections were significantly different for breed types using both fecal output estimating techniques.

Table 3. Daily forage intake of dry cows using fecal organic matter output estimates determined with the total collection and chromic oxide dilution techniques.

	Hereford Cows		Crossbred Cows	
Collection Period	Total Collection Technique	Chromic Oxide Technique	Total Collection Technique	Chromic Oxide Technique
		- - - - - - %[a] - - - - - -		
July, 1981	0.9[b]	0.9[b]	0.8[b]	0.8[b]
August, 1981	1.1[b]	1.1[b]	0.9[c]	0.9[c]
September, 1981	1.2[b]	1.1[bc]	1.0[c]	0.8[d]
1981 overall mean	1.1[b]	1.0[b]	0.9[bc]	0.8[c]
June, 1982	1.3[b]	1.7[c]	1.4[bc]	1.6[bc]
July, 1982	1.2[b]	1.5[c]	1.2[b]	1.4[bc]
August, 1982	1.2[b]	1.2[b]	1.1[b]	1.3[b]
September, 1982	1.5[b]	1.8[c]	1.3[d]	1.7[bc]
1982 overall mean	1.3[b]	1.5[c]	1.3[b]	1.5[c]

[a]Percent of body weight on an organic matter basis.
[b,c,d]Means within a row with different superscripts differ ($P \leq .10$).

Except for the September intake estimates using the total collection technique, the 1982 mean intake estimates, for all collection periods, showed no significant differences between breed types when the same fecal output estimating technique was used.

Forage Intake of Lactating Cows

Forage intake values for lactating cows are presented in Table 4. Mean crossbred values were larger than mean Hereford values for all collection periods except August, but only the mean values of the September collection were significantly larger. When mean intake values for all 4 collection periods were averaged, the mean intake values for the Hereford and crossbred cows are 1.9 and 2.1% of body weight/day, respectively. These mean values were significantly different. The decline that occurs in intake values from the June to the July and August collections was due to decreasing forage digestibility not decreasing fecal outut. The fecal output figures in Table 4 show that the mean fecal output was highest in August and July for the Hereford and crossbred cows, respectively. These are the two months when forage digestibility was lowest.

Table 4. Daily fecal output and forage intake of lactating Hereford and crossbred cows.

	Fecal Output		Forage Intake	
Collection Period	Hereford	Crossbred	Hereford	Crossbred
	%[a]			
June	0.9^b	1.0^b	2.1^b	2.4^b
July	1.0^b	1.1^b	1.9^b	2.2^b
August	1.1^b	0.9^b	1.8^b	1.6^b
September	0.9^b	1.0^c	1.9^b	2.3^c
Overall mean	0.9^b	1.0^c	1.9^b	2.1^c

[a]Percentage of body weight per day on an organic matter basis.
[b,c]Associated means within a row with a different superscript differ ($P<.10$).

Comparison of Forage Intake of Dry and Lactating Cows

Lactating cows had a significantly greater intake than their dry counterparts. Lactating Herefords had an average intake that was approximately 26% greater than the dry Herefords. Lactating crossbreds had an average intake that was 40% greater that the dry crossbreds. Table 5 provides a comparison of intake values for dry and lactating cows of both breed types.

Table 5. Daily forage intake of dry and lactating cows using fecal organic matter output estimates determined with the chromic oxide dilution technique.

Month	Dry Cows		Lactating Cows	
	Hereford	Crossbred	Hereford	Crossbred
	%[a]			
June	1.7^{b}	1.6^{b}	2.1^{c}	2.4^{c}
July	1.5^{b}	1.4^{b}	1.9^{c}	2.2^{c}
August	1.2^{b}	1.3^{b}	1.8^{c}	1.6^{c}
September	1.8^{b}	1.7^{b}	1.9^{c}	2.3^{a}
Overall mean	1.5^{b}	1.5^{b}	1.9^{c}	2.1^{d}

[a]Percent of body weight per day on an organic matter basis.
[b,c,d]Means within a row with a different superscript differ ($P < .10$).

Factors Explaining Variation In Intake Estimates

Forage intake values for all months and for all dry and lactating cows were regressed with the body weight, lactation status and breed type factors. Only the lactation status factor significantly explained a portion of the variation in intake between the dry and lactating Hereford and crossbred cows. The partial-r values for the body weight, lactation status and breed type factors were .02, .65 and 0.004, respectively. Forage intake values for all months and for all lactating cows were regressed with the body weight and breed type factors. In this regression only the breed type factor was significant in explaining variation in intake. The partial-r values for the body weight and breed type factors were -.23 and .34, respectively.

DISCUSSION

Fecal Output Estimating Technique

A method which accurately estimates the fecal output of a grazing animal, without encumbering it in some manner, has yet to be designed. Consequently, all indirectly derived estimates of fecal output must be compared with measurements derived from a less than perfect technique. Total fecal collection of a free-roaming animal obviously affects the animal, but the degree to which it alters its behavior and physiology is not well understood. Several factors must influence the degree to which an animal is affected by total fecal collections. Factors such as the duration of fecal collection, weight of the fecal bag and contents, environmental conditions and the size of the animal relative to the load of feces and the incumberance of the collection gear are important variables. Techniques which indirectly estimate fecal output may not encumber the animal at all, but these techniques have shortcomings which, to some degree, affect their accuracy (Harris et al., 1967). The chromic oxide dilution technique appears to have fewer shortcomings than other indirect techniques (Havstad, 1982). Its primary problems are variable recovery of chromic oxide in the feces and diurnal variation in its excretion rate (Raleigh et al., 1980). Both of these problems lead to inaccurate estimations of fecal output. Unfortunately, research on these problems in several states and by a number of different workers has not demonstrated reliable methods to avoid these shortcomings (Raleigh et al., 1980).

Comparisons of measured fecal output with chromic oxide derived estimates have produced variable results (Raleigh et al., 1980). Estimates reported in the literature have varied from an underestimate of 31% to an overestimate of 87%, but the estimates tend to be approximately 20% higher then measured values (Raleigh et al. 1980). When fecal output estimates were averaged by season, the differences between measured fecal output and estimated fecal output were smaller. As reported by Raleigh et al. (1980), by removing the large animal-day variation in chromic oxide estimates a closer relationship exists between the measured and estimated values. Although no overestimation of fecal output exists in the 1981 values of this study, a 14% and 17% overestimation occured in the 1982 values for the Hereford and crossbred cows, respectively.

Fecal Output Estimates

In studies of forage intake of Afrikander and Mashona cows grazing Zimbabwe veld, Elliot and Fokkema (1961) and Elliot et al. (1961) reported fecal output estimates for both dry and lactating cows. The chromic oxide technique was used for their organic matter based estimates. For the dry cows, Elliot and Fokkema (1961) and Elliot et al. (1961) reported fecal outputs of approximately 1.1 and 0.8% of body weight/day, respectively, for the larger Afrikander cows while the Mashona cows had a fecal output of 1.1 and 1.0% of body weight/day, respectively. For the lactating cows, Elliot and Fokkema (1961) and Elliot et al. (1961) reported that the Afrikanders had fecal outputs of 1.5 and 1.2% of body weight/day, respectively, while the Mashonas had fecal outputs of 1.7 and 1.3% of body weight/day, respectively. These fecal output estimates are considerably larger than those of this study. The dry Hereford and crossbred cows had fecal output estimates of 0.7 and 0.5% of body weight/day in 1981 and 0.8 and 0.7% of body weight/day in 1982, respectively. The lactating Hereford and crossbred cows had fecal outputs of 0.9 and 1.0% of body weight/day, respectively. Total daily fecal output on a weight basis is very similar between cows of this study and the Zimbabwe study. Afrikander and Mashona cows were approximately 40% lighter than the Hereford and crossbred cows, consequently, the smaller Zimbabwe produced about 40% more feces as a percent of body weight.

Fecal output remained relatively constant for dry and lactating cows throughout this study, as in the study of Elliot et al. (1961). Relatively constant fecal production is expected with diets of moderate to low quality. With diets of this nature, intake continues to gut fill and digesta passes through the system at a fairly constant rate.

Forage Intake

Using the chromic oxide derived fecal output estimates, dry Hereford and crossbred cows consumed approximately 1.0 and 0.8% of body weight/day, respectively in 1981 and 1.5% of body weight/day, for both breeds, in 1982. These estimates are somewhat smaller that those reported in other studies. Elliot and Fokkema (1961) estimated intake at 1.6 and 1.7% of body weight/day for dry Afrikander and Mashona cows, respectively. Holmes et al. (1961) estimated intake of dry Ayrshire cows at 1.8% of body weight/day. The dry Hereford and crossbred cows of this study were generally heavier than cows of the other studies and apparently consumed less forage relative to their body size.

Mean intake estimates for lactating Hereford and crossbred cows in this study were 1.9 and 2.1% of body weight/day, respectively. Values reported in the literature for lactating cows range from 1.6 to 3.2% of body weight/day. Holloway et al. (1979) reported values of 2.0 and 2.1% for lactating Angus cows grazing tall fescue and tall fescue-legume mix pastures, respectively. Holmes and Osman (1960) reported on intake of 2.3% of lactating Ayshire cows while Stehr and Kirchgessner (1976) reported an intake of 1.6% for lactating Simmental cows. Elliot and Fokkema (1961) reported estimates of 2.2 and 2.6% for lactating Afrikander and Mashona cows, respectively. Elliot et al (1961) reported estimates of 2.6 and 3.1% for lactating Afrikander and Mashona cows, respectively. Streeter et al (1974) reported values of 2.8, 3.1 and 3.2% for lactating Hereford, Brown Swiss and Charolais-Angus cows, respectively. Differences among these estimates reflect the accuracy of techniques used as well as differences in intake of dissimilar cows in unlike environments.

Lactating Hereford and crossbred cows consumed about 29 and 40% more forage, respectively than their dry counterparts. This is similar to the 25 and 32% increase in intake of lactating Afrikander and Mashona cows studied by Elliot et al. (1961). Field (1966) and Jones et al. (1965) found increases of 25 and 35%, respectively, for the lactating cows they studied. Increased intake of lactating cows is well documented in the literature (Hutton, 1963; Campling, 1966).

Leaver et al. (1969) and Smith and Baldwin (1974) observed the hypertrophy of the alimentary tract in lactating cows and Campling (1970) suggested that this occurs with endocrine changes associated with the beginning of lactation.

Factors Explaining Variation In Intake

When body weight, breed type and lactation status were considered as factors explaining variation in intake between dry and lactating cows, lactation status was the only significant factor. This contradicts the suggestion of Bines (1976) who stated that correlations between intake and milk yield were low, while correlations between intake and body weight are usually high. When body size and breed type were considered as factors explaining variation in intake of lactating cows, only the breed type factor was significant. This again suggests that tne different milk yield of the Hereford and crossbred cows was the most important factor in explaining their intake differences. Considering the large energy consumption required for milk production, it is not surprising that lactation would be such a significant factor affecting forage intake.

Energy Intake

For the cow, the energy cost of producing milk is approximately one Mcal of metabolizable energy/kg of milk produced (Blaxter, 1962; NRC, 1976). A related study, at the Northern Agriculture Research Center, estimated milk output of Hereford and 75% Simmental-25% Hereford cows through the 1982 summer grazing season (Casebolt et al., 1983). This study concluded that the Hereford cows produced approximately 11, 8, 6, and 5 kg/day during the June, July, August and

September collections, respectively. The crossbred cows produced approximately 12, 11, 10 and 9 kg/day during the June, July, August and September collections, respectively. The additional energy requirements (Mcal of metabolizable energy) for milk production is approximated by these milk production values. Milk production has a considerable energy requirement. At the higher levels of milk production, the additional energy needed to produce milk was approximately 80% of the maintenance energy requirements for these lactating Hereford and crossbred cows. McClymont (1967) suggests that total energy demand for maintenance, growth, milk secretion and exercise is the primary facilitory stimulus for phagic behavior. As the cow's total energy demand rises, her forage intake should also increase. However, with forage of low to medium quality, additional forage intake may be limited by the physical capacity of the reticulo/rumen and passage rate of the digesta.

Forage metabolizable energy content was approximately 2.4, 2.2, 1.9 and 2.3 Mcal/kg (OMB) (NRC, 1976; Church and Pond, 1974) in June, July, August and September of 1982, respectively. In June the average weight of the lactating Herefords was 441 kg and their forage intake averaged 2.1% of body weight/day. Therefore, they consumed about 22.3 Mcal of metabolizable energy/day. Average June weight of the lactating crossbred cows was 563 kg and they consumed and average of 2.4% of their body weight and 32.4 Mcal of metabolizable energy/day. The NRC (1976) metabolizable energy requirements for maintenance and lactation, for cows of this weight and milk production, are 23.8 and 27.4 Mcal of metabolizable energy/day for the Herefords and crossbreds, respectively. For July metabolizable energy consumption was estimated at 19.1 and 26.8 Mcal/day for the Hereford and crossbred cows, respectively. These values compare with NRC derived requirements of 21.1 and 26.2 Mcal of metabolizable energy/day for the Hereford and crossbred cows, respectively. August metabolizable energy intake estimates were 17.8 and 19.7 Mcal/day for the Herefords and crossbreds, respectively. NRC based requirements for the Hereford and crossbred cows, in August, were 19.5 and 25.8 Mcal of metabolizable energy/day, respectively. September metabolizable energy intake estimates were 20.7 and 31.0 Mcal/day for the Hereford and crossbred cows, respectively, while the NRC estimates that the Hereford and crossbred cows would require 18.5 and 24.8 Mcal/day, respectively. Estimated energy intake values, in this study, are on the average 5% below and 5% above the NRC values for the Hereford and crossbred cows. If the NRC based requirements are increased by 25-30% to account for additional energy expended by these free-roaming cows, then the energy intake estimates, of this study, are approximately 20% less than estimated energy requirements. In a recent study of energy intake of mature Hereford and crossbred cows, Ferrell and Jenkins (1982) found that energy requirements for maintenance, during mild weather, were substantially lower than the maintenance requirements reported by NRC (1976). Using the estimate provided by Ferrell and Jenkins for maintenance energy requirement (112 kcal ME/kg of metabolic body weight/day compared to the NRC value of approximately

133 kcal ME/kg of metabolic body weight/day), the energy intake estimates of this study are approximately 15% lower than estimated energy requirements.

The discrepancy between estimated energy intake and energy requirements may be due to several factors.First, milk production may have been lower, in the cows of this study, than the milk production values used in determining energy requirements for lactation. Different cows were used for estimating forage intake and milk production. Second, forage intake may have been underestimated. If this occurred, the underestimation may be due to underestimation of forage digestibility in the in vitro digestibility analysis. However, forage intake estimates for the dry cows were similar to literature values and the same digestibility values were used for dry and lactating cows. Lactating cows may have selected forage somewhat more digestible than the predominantly dry, esophageal fistulated, extrusa collection cows. Third, forage metabolizable energy content may have been underestimated, though this is unlikely, because literature values higher than those used are very uncommon for range forage. Further study on energy expenditures will improve the understanding of energy balance for these lactating Hereford and crossbred cows.

SUMMARY

During the summer grazing seasons of 1981 and 1982 dry and lactating Hereford and 75% Simmental-25% Hereford cows were used in fecal output estimation trials. Estimates of fecal output were obtained with the total collection and chromic oxide techniques. During these trials another group of dry, esophageal fistulated Hereford and 75% Simmental-25% Hereford cows were used to collect forage samples. These samples were then used for *in vitro* digestibility analysis to obtain estimates of the digestibility of forage grazed by the Hereford and crossbred cows in the fecal output estimation trials. These fecal output and forage digestibility estimates were then used to derive forage intake estimates for the dry and lactating Hereford and crossbred cows. These cows were grazed on rough fescue, Idaho fescue and bluebunch wheatgrass dominated range on the northwestern slopes of the Bearpaw mountains in north central Montana. The study area was similar to foothill range in northern Montana. The cows were part of the Hereford and crossbred herd maintained by Montana's Northern Agricultural Research Center (NARC) for productivity studies. With forage intake estimates derived from this study and production information on Hereford and 75% Simmental-25% Hereford cows in the NARC herd the productive efficiency of these cows can be determined.

Fecal output estimates were expressed as a percent of body weight/day on an organic matter basis. In 1981, mean fecal output of dry Hereford cows was 0.7 and 0.7 with both fecal output estimating

techniques. In 1982, mean fecal output of dry Hereford cows was 0.7 and 0.8 with the total collection and chromic oxide techniques, respectively. These means were significantly different. In 1981, mean fecal output of the dry crossbred cows was 0.6 and 0.5 with the total collection and chromic oxide techniques, respectively. These means were not significantly different. In 1982, mean fecal output of dry crossbred cows was 0.6 and 0.7 with the total collection and chromic oxide techniques, respectively. These means were not significantly different.

Forage digestibility was estimated at 39, 34, and 35% for the July, August and September collection periods of 1981. In 1982, forage digestibility was estimated at 59, 45, 41, 55% for the June, July, August and September collection periods.

Forage intake estimates were expressed as a percent of body weight/day. In 1981, forage intake estimates for dry cows were 1.1 and 0.9 for the Hereford and crossbred cows, respectively, using the total collection derived fecal output estimates. When the chromic oxide derived fecal output estimates were used, intake estimates were 1.0 and 0.8 for the Hereford and crossbred cows, respectively. These total collection derived estimates were not significantly different nor were the chromic oxide derived estimates. The 1982 total collection derived intake estimates were 1.3 for both breed types of cows, whereas, the chromic oxide derived estimates were 1.5 for both breed types. There was a significant difference between estimates derived with the two techniques. The lactating Hereford cows had a mean intake of 1.9 while the lactating crossbred cows had a mean intake of 2.1. These mean intake estimates were significantly different.

When a comparison of fecal output estimates was made among the 1981 mean fecal output values, the chromic oxide technique provided estimates similar to the total collection derived estimates. In 1982, this was not the case. The chromic oxide derived values were approximately 15% larger than the fecal output values determined with the total collection technique.

When intake values for all dry and lactating cows were combined and regressed with several characteristics of the study cows, only the lactation status factor was found to be significant in explaining variation in intake. Body weight and breed type were insignificant. When the intake values for lactating cows were regressed with body weight and breed type factors, only the breed type factor was significant. These relationships suggest that lactation and quantity of lactation had the most important affect on forage intake.

The mean metabolizable energy (ME) content of the range forage was estimated at 2.2Mcal/kg on an organic matter basis. If this assumption is correct then lactating Hereford and crossbred cows consumed approximately 19.2 and 26.3 Mcal of ME/day.

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LITERATURE CITED

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APPENDICES

Appendix A

List of plant species occurring in the study pasture.

	Scientific Bionomial	Common Name
Graminoids	*Agropyron dasystachyum*	thickspike wheatgrass
	Agropyron smithii	western wheatgrass
	Agropyron spicatum	bluebunch wheatgrass
	Bromus japonicus	Japanese brome
	Bromus tectorum	cheatgrass brome
	Carex eleocharis	needleleaf sedge
	Carex filifolia	threadleaf sedge
	Festuca idahoensis	Idaho fescue
	Festuca scabrella	rough fescue
	Koelaria pyrimidata	prairie junegrass
	Poa pratensis	Kentucky bluegrass
	Stipa comata	needleandthread
	Stipa columbiana	Columbia needlegrass
	Stipa viridula	green needlegrass
Forbs	*Achillea millifolium*	western yarrow
	Agoseris glauca	false dandelion
	Antennaria parvifolia	small-leaf pussytoes
	Artemisia frigida	fringed sagewort
	Artemisia ludoviciana	cudweed sagewort
	Astragulus bisulcatus	twogrooved milkvetch
	Balsomorhiza sagittata	arrowleaf balsamroot
	Campanula rotundifolia	harebell
	Erigeron glabellus	smooth fleabane
	Gaillardia aristata	gaillardia
	Galium boreale	northern bedstraw
	Geranium viscosissimum	sticky geranium
	Geum triflorum	prairiesmoke
	Grindelia squarrosa	curlycup gumweed
	Heterotheca villosa	hairy goldenaster
	Liatris punctata	dotted gayfeather
	Lithosperma ruderale	western gromwell
	Lomatium foeniculaceum	lomatium
	Lupinus species	lupine
	Monarda fistulosa	horse mint
	Phlox hoodii	Hood's phlox
	Potentilla fruiticosa	shrubby cinquefoil
	Potentilla hippiana	horse cinquefoil
	Psoralea lanceotata	lemon scurfpea
	Ratibida columnifera	prairie coneflower
	Rosa arkansana	prairie rose
	Seliginella densa	dense clubmoss
Cactus	*Opuntia polyacantha*	pricklypear

Shrubs & Trees	*Juniperus horizontalis*	creeping juniper
	Prunus virginiana	chokecherry
	Symphoricarpos occidentalis	western snowberry
	Pinus ponderosa	ponderosa pine

Appendix B. Table 6. Lactation status, milk production, body weight and forage intake information for free-roaming cows compiled from the literature.

Reference	Type of Pasture	Breed of Cow	Lactational Status	Milk Production (kg/day)	Body Weight (kg)	Forage Intake (% Body Weight)	Basis of Measurement[1]
Elliot & Fokkema (1961)	veld grassland	Afrikander	dry	-	533	1.5 (OMB)	TC/LR
		Mashona	dry	-	318	1.3 (OMB)	
		Afrikander	lactating	-	408	2.5 (OMB)	
		Mashona	lactating	-	295	2.6 (OMB)	
Hills (1968)	semidesert grassland	Hereford & Santa Gertrudis	-	-	436-439	1.7-3.3 (DMB)	LR/Cr_2O_3
Holloway et al. (1979)	tall fescue	Angus	lactating	8.5	458	2.0 (DMB)	Cr_2O_3/ADL
Holloway et al. (1979)	tall fescue-legume mix	Angus	lactating	8.3	472	2.1 (DMB)	Cr_2O_3/ADL
Holmes & Osman (1960)	ryegrass-clover mix	Ayrshire	lactating	14.4	513	2.3 (OMB)	FNI/Cr_2O_3
Holmes et al. (1961)	ryegrass-clover mix	Ayrshire	dry	-	537	1.8 (OMB)	FNI/Cr_2O_3
Kartchner (1975)	crested wheatgrass	-	lactating	-	523-615	1.6-2.9 (DMB)	TC/IVDMD
Streeter et al. (1974)	native meadow (Colorado)	Brown Swiss	lactating	10.3	473	3.1 (DMB)	Cr_2O_3/IVCWC
		Charolais x Angus	lactating	7.5	374	3.2 (DMB)	
		Hereford	lactating	6.0	363	2.8 (DMB)	
Stehr & Kirchgessner (1976)	-	Simmental	lactating	17.5	675	1.6 (OMB)	Agronomic

[1] TC = total fecal collection; LR = lignin ratio; Cr_2O_3 = chromic oxide; IVCWC = *in vitro* cell wall constituents; IVDMD = *in vitro* dry matter digestibility; FNI = fecal nitrogen index; ADL = acid detergent lignin.

Appendix B. Table 7. Prominent plant species occurring in the study pasture with estimates of their canopy coverage and importance in the community.

Lowland Areas			Upland Areas		
Species	Canopy Cover	Composition	Species	Canopy Cover	Composition
	---- %(SD) ----			---- %(SD) ----	
Poa pratensis	31(6)	71(33)	*Festuca scabrella*	10(13)	15(19)
Agropyron smithii	2(2)	3(2)	*Festuca idahoensis*	7(9)	10(13)
Festuca idahoensis	1(1)	1(1)	*Agropyron spicatum*	1	2
Stipa viridula	1(1)	1(1)	*Agropyron dasystachyum*	5(6)	8(9)
Carex eleocharis	1(1)	1(1)	*Stipa comata*	1	5(4)
Symphoricarpos occidentalis	5(7)	7(10)	*Carex filifolia*	9(4)	14(7)
Lupinus species	4(5)	5(7)	*Psoralea lanceolata*	6(7)	9(11)
Geranium viscosissimum	3(4)	4(6)	*Lupinus* species	11(7)	16(11)
Rosa arkansana	2(2)	3(2)	*Geum triflorum*	4(1)	5(1)
Geum triflorum	1(1)	2(1)	*Phlox hoodii*	4(1)	5(3)
Heterotheca villosa	1(1)	1(1)	Misc. species	10(6)	11(4)

[1]Rated microplots, as described by Morris (1973), were used to estimate canopy cover and composition.