Fecal output by calves of Tarentaise, Hereford and crossbred cows under range conditions
by Eric Thomas Miller

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

Abstract:
Fecal output (FO) was estimated for calves raised on different biological types of cows under range conditions. Fecal samples were collected for calves from Tarentaise (TT), Hereford x Tarentaise (HT), and Hereford (HH) cows over three periods during the 1992 and 1993 grazing seasons. Fifty-one calves were evaluated each year. Collection periods were June (PI)5 September (PII), and October (PIII). Estimates of FO were obtained using constant release Cr2O3 intraruminal boluses. Data were analyzed by period using least squares GLM. Main effects were breed of dam, breed of sire, age of dam (AOD), year, and sex of calf. Calf days of age (DOA), dam weight, dam milk production, and calf weight were tested as covariates. Mean fecal outputs were 452, 1573, and 2159 g/d, for PI, PII, and PIII, respectively. Breed of dam was important (P<.05) during PI and PIII with FO means for PI of 412, 512, and 493 g/d for TT, HT, and HH, respectively. Tarentaise FO was less than HT (P<.05) and HH (P=.06). Means for PIII were 1193, 2052, and 2960 g/d, for TT, HT, and HH, respectively, with lower FO for TT then HH and HT (P<.05) and HT having less FO than HH (P<.05). For PIII AOD was important (P<.05) and FO for calves from 2, 3, 4, and 5+ yr-old cows was 2474, 2746, 1611, and 1443 g/d, respectively. Calves from 2-and 3-yr-old cows had more (P<.05) FO than calves of 4-and 5-yr-old cows. Mean calf weights for PI, PU, and PIII were 106, 202, and 226 kg at 76, 170, and 1969, respectively. Regression of FO on calf weight was not important during PI (P>.05), approached significance (P= 16) for PU, and was 22.8 g/kg for PIII (P<.05). Calf age was important (P<.05) during PI. Calves in 1992 had higher FO (P<.05) than in 1993 for PI and PII. These results suggest that calves from high milk production potential dams have less fecal output than calves from dams with low milk production potential.

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ABSTRACT

Fecal output (**FO**) was estimated for calves raised on different biological types of cows under range conditions. Fecal samples were collected for calves from Tarentaise (**TT**), Hereford x Tarentaise (**HT**), and Hereford (**HH**) cows over three periods during the 1992 and 1993 grazing seasons. Fifty-one calves were evaluated each year. Collection periods were June (**PI**), September (**PII**), and October (**PIII**). Estimates of FO were obtained using constant release Cr_2O_3 intraruminal boluses. Data were analyzed by period using least squares GLM. Main effects were breed of dam, breed of sire, age of dam (**AOD**), year, and sex of calf. Calf days of age (**DOA**), dam weight, dam milk production, and calf weight were tested as covariates. Mean fecal outputs were 452, 1573, and 2159 g/d, for PI, PII, and PIII, respectively. Breed of dam was important ($P<.05$) during PI and PIII with FO means for PI of 412, 512, and 493 g/d for TT, HT, and HH, respectively. Tarentaise FO was less than HT ($P<.05$) and HH ($P=.06$). Means for PIII were 1193, 2052, and 2960 g/d, for TT, HT, and HH, respectively, with lower FO for TT then HH and HT ($P<.05$) and HT having less FO than HH ($P<.05$). For PIII AOD was important ($P<.05$) and FO for calves from 2, 3, 4, and 5+ yr-old cows was 2474, 2746, 1611, and 1443 g/d, respectively. Calves from 2-and 3-yr-old cows had more ($P<.05$) FO than calves of 4-and 5-yr-old cows. Mean calf weights for PI, PII, and PIII were 106, 202, and 226 kg at 76, 170, and 196 d, respectively. Regression of FO on calf weight was not important during PI ($P>.05$), approached significance ($P=.16$) for PII, and was 22.8 g/kg for PIII ($P<.05$). Calf age was important ($P<.05$) during P1. Calves in 1992 had higher FO ($P<.05$) than in 1993 for PI and PII. These results suggest that calves from high milk production potential dams have less fecal output than calves from dams with low milk production potential.

CHAPTER 1

INTRODUCTION

The primary economic product of beef cow-calf producers is calf weight at weaning (Lindholm and Stonaker, 1957). Therefore, producers try to optimize cow-calf performance to produce the most product (weaning weight) while maintaining an efficient cow herd. Cow-calf performance historically has been measured by production traits such as weaning weight, average daily gain, yearling weight and the ability of the dam to rebreed. Feed costs are an important economical component for the cow-calf producer but little research has been conducted in the area of forage intake of cow-calf pairs under native range conditions in Montana.

Dam milk production has been identified as accounting for a large portion of the variability in calf weaning weights (Neville, 1962; Gregory et al., 1965; Rutledge et al., 1971; Wyatt et al., 1977; Butson et al., 1980). Some studies have concluded calves of dams producing high quantities of milk consume less forage than calves of low milk producing dams (Lusby et al., 1976; Wyatt et al., 1977) and calves consuming less milk increase the amount of forage they consume (Le Du and Baker, 1979; Boggs et al., 1980). Ansotegui et al. (1990) found that calves receiving lower levels of milk consumed more forage than calves from high milking cows. Less research has been undertaken to determine the extent to which calves utilize forage under range conditions and how it effects their performance at weaning (Boggs et al., 1980; Grings et al., 1995). Identifying biological cow types which are most efficient under specific conditions would prove beneficial to the producer and to the beef industry. The purpose of this study was to estimate fecal output of calves reared by dams of different biological types for milk production in foothill rangelands.

CHAPTER 2

LITERATURE REVIEW

Traits Affecting Calf Intake

Intake

Young animals have greater nutrient requirements on a unit of body weight basis than those of adults (Allison, 1985) which are met by higher feed turnover rates (Hungate, 1966). Higher turnover rates allow the animal to have higher intakes, thus providing greater nutrient quantities to the animal. Increasing intake has been proposed as a method of increasing animal performance (Allison, 1985). The young ruminant begins to ruminate by 11to14 days of age if forage or concentrates are available (Lyford and Huber, 1988). Ruckebusch, (1988) suggest complete rumen development at 3 to 5 weeks of age. Young ruminants select a diet higher in CP and lower in ADF than mature animals (Horn et al., 1979; Grings et al., 1995) which may be due to experimental grazing (Roy, 1959). Calves may be more selective due to smaller mouth parts, thus smaller bites (which allows them to consume only the higher quality leaf portions (Nelson and Moser, 1994) of forage.

Ruckebusch (1988) states rumen development is dependent upon diet composition. Kaiser (1976) found reticulo-rumen weights were lower for calves receiving high milk replacers levels as compared to those receiving low milk replacer levels at 12 weeks of age. Broesder et al., (1990) suggested reticulo-rumen development is increased as intake of milk replacer was decreased. Ansotegui (1986) found calves began to actively ruminate before 45 days of age and organic matter intake per unit of body weight is similar to mature animals. Bailey and Lawson (1981) reported that by 44 days of age calves on native range in Southern Alberta were drinking water and consuming forage, but 86% of digestible energy was from milk. Sims et al. (1975) found that early in the grazing season forage accounted for only 20% of energy for gain for calves grazing Colorado high plains grasslands while by September forage accounted for 50% of the energy for gain. Forage intake of calves on low quality pasture is thought to be limited by bulk fill (Sowell et al., 1995).

Gain and Milk Intake

Calf performance from birth to weaning is influenced by many variables. Many researchers have attributed up to 60% of weaning weight variation to dam's milk production (Neville, 1962; Rutledge et al., 1971). Other researchers have reported positive correlations between weaning weight and milk production ranging from 0.12 to 0.88 (Knapp and Black, 1941; Neville, 1962; Furr and Nelson, 1964; Christian et al., 1965; Totusek et al., 1973; Kress and Anderson, 1974; Baker et al., (1) 1976; Lusby et al., 1976). The wide range of correlations reported may be due to differences in nutritional levels of the calves. Calves in the research by Furr and Nelon, (1964) were supplimented with creep feed, thus increasing their non-milk intake levels and possibly reducing the influence of milk on their weaning weights.

Increased milk production has been related to decreases in reproductive performance of the cow (Boggs et al., 1980) and increased digestible energy requirements (Marshall et al., 1976). Specifically, Boggs et al., (1980) found rebreeding was delayed 1.4 days for polled Herefords grazing native bluestem range for every additional 1 kg of milk produced. Because of the demands of higher milk production, range cow/calf operations need to evaluate the amount of milk production in their herds.

Calves maintain a strong relationship between milk intake and weight gain during the first few weeks of life while they develop their intake capacity (Baker et al., 1976) and because of their refusal of solid feed (Roy, 1959).

Calves receiving high levels of milk have greater growth rates than calves on low milk producing dams (Baker et al., 1976; Adams et al., 1993). Wyatt et al. (1977) in a drylot study reported, Angus x Hereford (AxH) cross calves raised on high producing dams consumed 21% more total daily digestible energy and required 3.6 kg more milk per kg of gain than calves on low milk producing dams. In the same study, Fresian (F) X Charolais (C) calves on high production milk dams consumed 38% more DE, consumed 3.3 kg more milk per kilogram gain, resulting in an additional 21.7 kg of milk for each additional kilogram of gain and were 51% less efficient compared to the calves receiving low milk. Live weight gains of 55g and 81g, have been reported per kilogram of milk consumed for H X F calves in a housed environment (Barker et. al. 1976; Le Du et al., 1976). Kaiser (1976) reported calf weaning weights, pre-weaning gains and carcass weights increased with increases in the quantity of whole milk fed for H X dairy crossed calves weaned at 12 weeks. Boggs et al. (1980) reported a 7.20 kg increase in 205 day adjusted weaning weight for every 1 kg increase in milk per day with an average daily gain of .34 kg/day.

Milk and Forage Intake

Forage intake, forage digestibility, milk intake and calf age are interrelated with respect to calf performance (Lusby et al., 1976). Calf milk intake declines steadily throughout the grazing period after the calf reaches 40 to 50 days of age (Peischel, 1980; Holloway and Butts, 1983; Sowell et al., 1996). Calf forage intake increases during the grazing season as milk production levels decrease and the calves become older (Baker et al., 1981). Melton et al. (1967); Ansotegui (1986), and Sowell et al. (1996), have suggested milk intake and calve weight gain are most highly correlated during the first 60 days of a calf's life. Forage intake is negatively related to average daily gain during the first 2 months of age for calves (Boggs et al., 1980). Le du et al. (1976) and Baker et al. (1976) suggest a greater reliance on forage during the grazing period by calves receiving lower quantities of milk. Lusby et al. (1976) found dairy cross calves consumed more milk and less forage than did Hereford calves under equal range conditions. In a feedlot study, Lusby et al. (1976) determined less creep feed was consumed by calves receiving higher levels of milk, but on range calves on low milk producing dams consumed more cellulose than calves on high milk producing dams. Marshall et al. (1976) reported calves receiving more milk tended to consume less creep TDN and that milk production accounted for a large part of the variation in creep intake.

Baker et al. (1976) found milk intake and forage intake to be inversely related from birth to weaning. Lusby et al. (1976) found milk intake was negatively correlated with cellulose and creep intake. Milk intake has been found to be negatively related to forage intake by 2 to 6 month old calves (Boggs et al., 1980) and from 3 to 5 months of age increased forage intake improved calve performance (Ansotegui et al., 1990). On native

Kansas bluestem range, 2 month old Polled Hereford calves consumed .03 kg/day less grass and 6 month old calves consumed .07 kg/day less grass for each kilogram of milk consumed (Boggs et al., 1980). Ansotegui et al., (1990) found calves consumed 0.3 kg more forage in July and 0.6 kg more forage in August and September for each kilogram reduction in milk intake.

Roy (1958) suggested calves become independent grazers by 56 days of age, while Ansoteguei et al. (1990) suggested calves may become self sufficient between 70 and 100 days. Bailey and Lawson (1981) found calves on range received only 19% of daily digestible energy from milk at weaning and that forage dry matter intake increased from 0.5 kg a day to 5.5 kg a day at weaning, as determined by the difference in DE required and that supplied by milk, assuming 80% dry matter this equates to 6.9 kg a day. Kartchner et al. (1979) reported spring calves initially consumed .12 kg of forage a day at approximately 30 days of age and increased to 1.71 kg/day by approximately 150 days of age.

Dam Factors Affecting Forage Intake

Maintenance energy requirements account for 65 - 75% of total annual energy requirements for beef cows independent of breed type (Ferrell and Jenkins, 1985; 1987). They define maintenance as:

> "The energy required for zero body energy change (energy stasis) or feed energy required for zero body weight change (weight stasis)."

Research has shown energy requirements of various biological types differ during lactation (Ferrell and Jenkins, 1985) though they may be equal during non lactation periods.

Maternal milk production has been used as a variable to classify cow types into biological type classifications (Holloway et al., 1975; Notter et al., 1978; Ferrell and Jenkins, 1984; Montano-Bermudez and Nielson, 1990). Maintenance requirements for different biological types may be similar, but as milk production increases, energy requirements also increase (Ferrell and Jenkins, 1985; Montano-Bermudez and Nelson, 1990).

Ferrel and Jenkins (1985) suggested that there are differences in energy requirements for maintenance between breeds due to their body condition, previous nutritional level, and genetic potential for milk, with those of higher milk potential having higher maintenance requirements. Ferrell and Jenkins (1984c) reported breed differences for metabolizable energy requirements between Hereford and Simmental for maintenance. Taylor et al. (1986) suggested the maintenance efficiency of a cattle breed decreased as its milk production increased.

Similar cattle genotypes can be categorized as biological types and classified for biological efficiency by comparing different genetic potentials for growth and milk production against forage intake (Ferrel and Jenkins, 1987). Biological efficiency has been explained as the "expression of calf performance relative to intake by the cow" (Kattnig et al., 1993). Havstad et al. (1987) advocated an equation for biological efficiency which includes reproductive measures:

$$\text{Biological efficiency} = \frac{\text{Adj. Calf weaning weight per cow exposed}}{\text{OMI}}$$

Differences in environments have been found to alter biological efficiency of different biological types of cattle (Kattnig et al., 1993) with lower producing animals generally having an advantage under restrictive or low forage quality environments (Ferrell and Jenkins, 1985). Adams et al. (1993) reported native rangelands and seeded rangelands in the Northern Great plains lack adequate nutrient levels during late summer grazing to support maintenance and lactation of high milk producing cattle. Tarentaise and Hereford x Tarentaise cows have been reported to produce more (average = 3.0 kg/d) milk under equal range conditions in northern Montana than Hereford dams (Kress et al., 1996). Katting et al. (1993) suggested that cow efficiency may decline if forage nutrient requirements are not adaquate to meet lactation and maintenance requirements.

Montano-Bermudez et al. (1990) found high milking cows weaned heavier calves than low milking cows, but energy requirements for maintenance were 12% greater on a metabolic body weight basis for the biological types with increased milk production potential during gestation and lactation. Adams et al. (1993) reported high milk producing cows in Eastern Montana lost more (P<.01) weight and body condition between the end of the breeding season and weaning than low milk producing cows. In the same study high milk producing cows lost body condition, while low milking cows maintained body condition during and after the breeding season. These results agree with those of Ferrell and Jenkins, (1984) who reported energy requirements for high milk potential cows tended to be higher than low milk potential cows.

Mantano-Bermudez and Nielson (1990) suggested maintenance requirements are positively related to milk production and milk production is negatively related to production efficiency to weaning for crossbred cows. Marshall et al. (1976) reported a positive relationship between milk production and efficiency to production. Kattnig et al. (1993) in a study to evaluate factors which might effect cow productivity were unable to determine a constant relationship between milk production potential and efficiency. They suggested these findings were due to insufficient variation in milk production potential among the cows.

Variation in milk production potential may account for between 23 and 70% of the variation in energy required for maintenance among different biological cow types (Taylor et al., 1986; Ferrell and Jenkins, 1987; Montano-Bermudez et al., 1990).

In a study comparing low milking Shorthorn x Angus, medium milking Red Poll x Angus, and high milking, Milking Shorthorns x Angus, biological type cow/calf pairs for efficiency to weaning, Montano-Bermudez and Nielson (1990) found efficiency was highest for the low milk producing cows. They also reported calves from the medium and high milking groups required 8 and 5% more energy to slaughter than the low milking group and consumed 9 and 12% more energy during the pre-weaning period then calves from the low milking dams.

Dam milk production is a variable which can be controlled by the producer. When deciding on the milk production potential for a given herd, the producer needs to weigh the advantages of high verses low milking cows. The decision needs to include the management strategy for the sale of calves, as well as the environment the cattle will be utilizing. There is not a clear cut best choice for every operation.

Methods of Estimating Forage Intake

Ruminant efficiency and productivity are major factors which need to be considered when determining biological cow type for a given environment. One method used to evaluate how different cattle utilize their environment is to measure forage intake. Allison (1985) stated:

> Variation in voluntary forage intake is undoubtedly the major dietary factor determining level and efficiency of ruminant production. This variation is largest and least predictable for grazing ruminants. Range ruminant productivity and efficiency is relatively low due, in part, to intake limitations; therefore, productivity could probably be increased most by increasing intake.

No single technique is acceptable for the determination of forage intake by grazing ruminants. A technique that works for one environment may be inadequate for another due to changes in range conditions. Techniques used for range grazing trials have been characterized by relatively low precision, high labor and a sensitivity to bias (Langelands, 1975).

There is not a method available to directly quantify the quantity of forage intake by grazing animals, instead some type of estimate of forage intake must be employed. Ratio techniques are most commonly used for grazing studies. As stated by Cordova et al. (1978):

> Ratio techniques involve the calculation of digestibility and fecal output data through their ratio to an "indigestible" indicator or marker. Indicators may occur naturally in the forage (internal indicator) or may be administered in known amounts (external indicator). Internal indicators are more frequently used for estimating digestibility, while external indicators are used more in fecal output estimates.

The use of external markers have been tested and used extensively in the study of ruminant forage intake under range grazing conditions.

The estimation of forage intake may be calculated on either a dry matter or organic matter basis with the use of the following formulas:

Dry Matter: (Pond et al., 1978)

$$\text{dry matter intake} = \frac{\text{fecal dry matter output}}{1 - \text{forage digestibility}}$$

Organic Matter: (Cordova et al., 1978)

$$\text{organic matter intake} = \frac{\text{fecal organic matter output}}{\text{\% organic matter indigestibility}}$$

Most researchers have reported organic matter intake for grazing situations due to the high levels of ash associated with range forage.

The estimate of organic matter intake relies on the ratio of forage digestibility and fecal output. Forage digestibility can be estimated by various techniques. Forage samples may be collected by hand clipping samples of forage from the range utilized in the study, but this method is believed to be an inaccurate technique in that it may not represent the actual selection of forage species that would be chosen by grazing animals (Lesperance et al., 1960). The method of hand clipping may result in forage digestibilities lower than those selected by animals. Kartchner and Cambell (1979) reported grazing animals select forages higher in quality than those which are hand clipped.

Another method of obtaining forage samples has been with the use of esophageal fistulated animals (Holechek et al., 1982). This procedure has it limitations in that forage samples may be contaminated by saliva, decreasing digestibility estimates (Holechek et al. 1982), and it has been reported that fistulated animals may not graze the same species compositions as the rest of the research animals (Burns et al., 1994).

Ruminally cannulated cattle have also been used to collect forage samples. This method allows for the analysis of forage as chosen by the animal, but it too has limitations. The procedure is labor intensive and requires greater animal handling than esophageal cannulated animals. Cannulated animals are generally dry lotted the night before the collection, then the rumen is evacuated and the cattle are turned out for a period of 30 minutes to 1 hour during which time they are allowed to graze. The animals are subsequently brought back to chute where the rumen is emptied and the original contents are replace. Deficiencies in this technique have been reported for how well the samples collected represent the non-cannulated animals. Holechek et al. (1982) reported that animals with empty rumens may be less selective when allowed to graze. Cannulated cattle are usually maintained separately from the experimental animals and therefore may not travel as far as animals which are not gathered on a regular basis, thus, they may not have the same grazing patterns. Goetz et al. (1990) reported recovery of rumen contents is not a useful estimate of dry matter intake. Recent studies have reported ruminally cannulated animals graze species which are representative of forage species grazed non-cannulated cattle in the same pasture.

Estimating Digestibility

There are two methodologies primarily used for the estimation of forage sample digestibilities: in-situ digestion with ruminally cannulated animals and in-vitro digestion.

The two stage in-vitro technique (Tilley and Terry, 1963) has become the most commonly used method for estimation of forage digestibility (Holechek et al., 1982). Areas or possible variation when using this technique include animal to animal variation, animal diet, time of animal feeding, and time of rumen inoculum removal. In a sheep digestion trial, it has been reported that variation due to animals is high (Aryes,1991) and that there is not a significant amount of variation due to animals (Engels and van der Merwe, 1967). Aryes (1991) reported animal effects were greater when donor animals were fed different basal rations, indicating the diet of inoculm donnor animals may alter in-vitro digestibility estimates if the diets are different than the forages to be analyzed.

Differences in inoculum are the major source of low precision and variation with the in-vitro technique (Barnes, 1967). The animal(s) from which the inoculum are obtained should be on a diet similar to that which is being digested (Ayres, 1991) because it may better represent the conditions under which the animals will be utilizing the feed. Dhanoa and Deriaz (1991) suggested the addition of nitrogen in the form of urea to sustain the microbial populations in the test tubes if the donor animals are consuming a low protein diet. It has been reported that microbial activity is greatest 8 to 12 hours post feeding and that inoculum collections should be made within 18 hours of the last feeding (Dhanoa and Deriaz, 1984; Ayres, 1991). Kartchner and Cambell (1979) suggest the in vitro technique is best suited for determining relative differences in digestibility between groups of forage samples.

In situ digestion uses ground forage samples in nylon bags and placed in ruminally cannulated animals with percent disappearance measured to determine digestibility. The procedure is capable of measuring rate and extent of digestion depending on the length of time the samples are left in the rumen. Karchner and Cambell (1979) suggested the method only be used to determine relative differences between forages and not for estimating forage digestibility. Judkins et al. (1990) suggested there is not a single technique which is applicable across all forages and that the technique used should be selected based on what type of forage was being evaluated.

Estimating Fecal Output

Fecal output can be estimated with the use of external markers, or by total fecal collection. Historically, total fecal collection has been the basis by which forage intake has been estimated. Total fecal collection is labor intensive and the use of external harnesses and collection bags may limit its usefulness for range grazing studies (Cordova et al., 1978). The apparatus may alter grazing patterns (Fisher et al., 1986) and incomplete fecal collection during times of the year when forage moisture levels are high (Burns et al., 1994). External markers are elements not found in forage which are not absorbed by the animal such as chromic oxide, ferric oxide, silver sulfide, and rare earth metals animal (Pond et al., 1987). Markers may be fed as a supplement or administered in gelatin capsules to the animal in a known quantity or by the use of a constant release bolus.

Three methods have been advocated for the administration of external markers 1) daily administration of the marker, 2) pulse dosing, 3) constant release bolus (CRD). Daily administration of a marker is used to estimate fecal output, while pulse dosing as described by Paterson and Kerley (1987), can predict fecal output, rate of passage, mean retention time in the gut and fill of undigested dry matter by employing the appropriate model.

Pulse dosing (single dose) of a marker requires constant sampling over a 110 hour period with samples taken at 2 to 5 hour intervals to develop a predicted fecal excretion curve (Pond et al., 1987). The requirement for multiple fecal samples at short time intervals may disrupt the animals natural grazing behavior (Fisher et al., 1976). The interruptions in grazing may alter digestive kinetics (Burns et al., 1994) and thus interpretation of excretion curves must be interpreted carefully due to diurnal variation (Paterson and Kerley, 1987)

Daily administration of a marker requires an animal to be dosed either once or twice daily for at least five days prior to fecal sampling (Pond et al., 1987). To reduce the influence of diurnal variation, samples should be taken for three to seven days to obtain a mean marker concentration from which fecal output can then be estimated. Hardison and Reid (1953) reported diurnal variation in ruminants can increase chromium concentrations in feces which may bias fecal output estimates.

Daily administration of markers has associated problems. The technique is labor intensive, and except in winter, animals grazing range generally are not supplemented in the west. Thus animals must be gathered daily and restrained for administration of gelatin capsules. Increased handling of the animals for either marker administration or fecal collections has been shown to have adverse effects on grazing patterns which may bias results (Cochran et al. 1987; Fisher et al., 1976).

Diurnal variation is the change in digesta passage rate due to out flow from the rumen after eating. The daily variation in digesta flow can cause variation in chromium flows, thus under or over estimating fecal output (Sprinkle, 1992). Hardison and Reid, (1953) compared fecal output of hand fed steers to grazing steers dosed daily with 10g of Cr_2O_3 in gelatin capsules for 10d prior to sampling. They found fecal output varied throughout the day following the steers pattern of grazing. The grazing animals had either higher or lower chromium recovery levels than the hand fed steers, with higher chromium levels recorded during periods of low grazing and lower recovery levels at high grazing times.

Methodologies have been developed in an attempt to reduce the influence of diurnal variation on estimated fecal output. Two techniques which have received the most interest are chromium mordanted forage fiber or paper, and the use of constant release boluses.

Chromium impregnated paper or fiber is administered to the animal and is thought to have flow characteristics similar to forage particles (Pond et al., 1987). Kiesling et al. (1969) reported 20 to 30% chromic oxide impregnated paper was not effective at reducing diurnal variation in grazing steers and Nelson and Green (1969) reported similar results with the same paper for feedlot fed steers. Pond et al. (1987) advocate the use of 6 to 8% chromium mordanted to forage fiber. They reported this amount of chromium does not increase the density of the forage and allows it to flow with unmarked fiber.

The most recent advance in chromic oxide administration for grazing trials has been the development of the constant release boluse (CRD) by R. H. Laby (Harrison et al., 1981) marketed as "Captec Chrome", Nufarm Ltd., Auckland, NZ. This device has advantages over methods which require daily handling of animals in that animals are bolused on day one and no further handling is required for 7 to 10d while chromic oxide concentrations equalize (Parker et al., 1989). Several researchers have evaluated the CRD for accuracy of dosage and its ability to remove diurnal variation.

In experiments with penned sheep and one experiment with grazing cattle comparing twice daily dosing of gelatin capsules and CRD, Laby et al. (1984) reported correlation coefficients of .997 and greater for estimated release rate and actual daily release rate of the CRD. Additionally they reported diurnal variation was greatly reduced with the use of the CRD as compared to twice daily administration of gelatin capsules.

Diurnal variation has been found to be reduced in sheep (Furnival et al., 1990a; Parker et al., 1991) and cattle (Brandyberry et al., 1990) with the use of CRD's as compared to gelatin capsules. Furnival et al. (1990a) reported the CRD to be more accurate in estimating fecal output when a grab sample was taken at a specific time as compared to compositing fecal samples of the same time from gelatin capsule dosing.

Adams et al. (1991) conduced two studies with beef steers over a 20 day period to compare CRD fecal grab sample and total fecal collection methods for fecal output estimates. One study was conducted on irrigated tall wheatgrass pasture and the second was carried out on a native range pasture. In both experiments CRD grab samples were within 10% of total fecal collections. They concluded the CRD was a viable method for estimating fecal dry matter output in grazing trials, but that fecal output was overestimated with dormant native plants and that different forages may affect the release rate of the boluses causing inconsistent chromium flow rates from the rumen.

The CRD has been found to overestimate (Butinx et al., 1990; Pond et al., 1990) actual fecal output with grazing sheep. Butinx et al. (1990) also stated the CRD was not able to consistently estimate fecal output and Pond et al. (1990) reported the CRD was not a good predictor of total fecal output.

Three trials comparing twice daily administration of gelatin capsules and CRD with sheep restrained in metabolism crates and fed alfalfa pellets ad libitum (Hatfield et al., 1991) reported both methods to overestimate fecal output. In 1 of 3 trials the CRD was found to be inaccurate in estimating total fecal output. The standard error was 2.4 times greater for the CRD than the gelatin capsules. However, Hatfield et al. (1990b) reported that under some grazing conditions with sheep the CRD was accurate, and that under all grazing conditions the CRD was precise. These authors recommend total fecal collection on a sub-sample of animals to verify and adjust fecal output estimates.

The constant release Cr_2O_3 bolus has merit for use in grazing situations. While they have been found to overestimate fecal output, they have also been found to be fairly reliable at reducing diurnal variation. For studies of groups of animals on the same range, the constant release bolus should be useful because the overestimation of fecal output will be relative among animals. For individual animal evaluation, either total fecal collection on a subset of animals or the use of rumenally cannulated cattle should be used to calibrate the devices. The constant release bolus has advantages for grazing trials. Because the boluses are only administered once the amount of handling the animals is reduced, which would decrease alterations in animal grazing patterns (Cochran et al., 1987).

CHAPTER 3

MATERIALS AND METHODS

Sampling of Cows and Calves

Fifty-one Phase II calves were randomly selected from three biological types of dams and were used in each of 2 yr from the Northern Agricultural Research Center herd located near Havre, Montana. The biological types of dams were straightbred Tarentaise (TT), F_1 reciprocal crosses (HT), and straightbred Hereford (HH). Each dam breed group was represented by 17 individuals. On average calves within each dam breed group were raised on five 2-yr-old, six-3-yr-old, and six 4-yr-old or older dams. Calf numbers by breed of dam are presented in table 3.

Table 3. Number of calves by breed of Dam

Breed of Dam	PI	PII	PIII
TT	26	7	11
HT	30	15	16
HH	26	19	16
Totals	82	41	43

Pasturing

Calves were kept with their dams for periods I and II in an 80 ha pasture with a stocking rate of 2.1 ha/AUM, where forage availability was not a limiting factor on intake. Calves were weaned the first week of October and moved to a lowland meadow pasture for 2 wk prior to the third collection period. The pastures are located in the Bears Paw mountain range in north central Montana, the area is classified as a Forest-Grassland complex of the western glaciated plains. Vegetation in lowland meadows is primarily Kentucky bluegrass (Poa pratensis) while upland vegetation consists of rough fescue (Festuca scabrella), Idaho fescue (Festuca idahoensis), bluebunch wheatgrass (Agropyron spicatum, and ponderosa pine (Pinus ponderosa) overstory. Mean pasture elevation is 1300 meters with slopes of 0 to 40 percent. Annual precipitation was 40.5 cm in 1992 and 60.7 cm in 1993 with an average of 50.6 cm for the two years.

Breeding

All calves were progeny of HH, TT, and HT Phase I cows were bred in a 45 d breeding season. Heifers were bred by natural service and older cows by artificial insemination. Sires were Hereford, Tarentaise and F_1 bulls selected according to the index: I = YW - 3.2BW (Dickerson et al., 1974) with the restriction that birth weights were less than 45 kilograms. Calving began in late February and was completed in late mid April with a mean calving date of 26 March. The mating plans are represented in Tables 2 and 3.

Table 2. Mating of Foundation cows[a] to Phase I calves (Kress et al., 1995)

	H	T
H	HH	HT
T	HT	TT

[a] H = Hereford; T = Tarentaise

Table 3. Mating of Phase I cows[a] to produce Phase II calves (Kress et al., 1995)

	HH	HT	TT
HH	1H1H	3H1T	1H1T
HT	3H1T	1H1T	3T1H
TT	1H1T	3T1H	1T1T

HH = Hereford; HT = Hereford x Tarentaise; TT = Tarentaise

Sires were randomly assigned dams on a within age of dam and breed group basis. Foundation cows were randomly mated to 17 Hereford (H) and 16 Tarentaise (T) sires to produce Phase I calves. Phase I cows were randomly mated to 6 Hereford (HH), 6 Tarentaise (TT), and 6 F_1 (HT) sires resulting in Phase II calves. Natural service breeding in individual breeding pastures was used for first calf heifers. Sires comprised of Hereford, Tarentaise and F_1 bulls selected according to the index of I = YW - 3.2BW (Dickerson et al., 1974) with the additional requirement that birth weight was less than 45 kilograms. Calving began in February and was completed in late April or early May with a mean date of late March. Calves were weighed at the time of the second fecal grab sampling.

Forage Sample Determination

Hand clipped forage samples taken from eight locations representing north and south facing aspects and four elevations representing bottom, lower, middle and upper slopes were used to determine forage dry matter digestibility for the grazing season. Forage samples were clipped at times corresponding to fecal collections P1, June; P2, September; P3, October. Five forage samples were taken per site. Hoops (.5 m^2) were tossed at random and forage cut to 1 inch stubble height and separated into grass and forbs. Standing dead material was not removed.

Forage samples were ground through a 1 mm screen using a Wiley mill. In-vitro dry matter digestibility (IVDMD) was determined using the 2 stage Tilley and Terry in vitro technique in triplicate as modified by Barnes (Harris, 1970). Rumen fluid was from two ruminally cannulated cows on grazing improved summer pasture.

Fecal Output

Daily fecal output (FO) was measured during three periods throughout a grazing season in 1992 and 1993. The three periods were June (PI), September (PII), and October (PIII). Calf weights were measured at the same time fecal samples were taken. Fecal output was estimated using a constant release intraruminal bolus (Captec Chrome®, Nufarm, Auckland, NZ.) of chromic oxide (Cr_2O_3) designed for use in sheep to 100 kilograms. Three fecal grab samples were taken at three day intervals following a 10 day equilibrium period post bolusing. Samples were collected on days 10, 13, and 16. Fecal samples were frozen and later analyzed for DM, OM, Ash (AOAC) and Cr_2O_3 concentrations. Fecal output was estimated using the following formula (Burns et al., 1994):

$$FO\ (g/d) = \frac{\text{Cr release rate (g/d)}}{\text{Cr content in feces (g/g)}} * \%OM$$

Fecal output from forage was determined by subtracting the fecal contribution from milk. Milk fecal output was determined from the assumptions that milk consists of 12% solids and milk solids are 92% digestible (Baker et al., 1976).

Calves were bolused in the morning and retained in drylot for several hours. Calves which regurgitated boluses were immediately rebolused. Calves were determined to have lost a bolus if a number coded bolus was found or if an unusually low chromium concentration reading was recorded by the atomic spectrophotometer during laboratory analysis. Fecal output estimates were determined to be outliers and removed from the analysis if the atomic absorption (AA) readings were not within the standard curve or if there was a consistent decrease in the AA values for an individual within a period. All observations for those calves were removed from the analysis for the coinciding period. The outlying observations were thought to be due to regurgitated boluses, boluses which malfunctioned, or insufficient chromium oxide concentrations for the quantity of forage consumed.

Fecal Sample Analysis

Fecal samples were analyzed for dry matter (DM), organic matter (OM), ash, and chromium oxide (Cr_2O_3) content. Fecal samples were oven-dried at 60° C for 48 h and subsequently ground through a 2 mm screen in a Wiley mill. Fecal dry matter and organic matter were determined according to AOAC (1990) procedures. Fecal samples were analyzed by individual sample within period by Atomic Absorption spectrophotometry procedure (Williams et al., 1962) using a 1 gram sample. Five replications per period were conducted representing 1 duplicate per 10 samples to measure the repeatability and accuracy of the procedure.

Chromium Determination

Chromium oxide concentrations were determined for the fecal samples following the procedure described by Williams et al. (1962) and modified by Swensson et al. (1995). Samples were analyzed on a Perkin - Elmer 303 atomic absorption spectrophotometer with settings as recommended in the Perkin - Elmer Analytical Methods Handbook (1973). A regression line was fitted using Chromic oxide dilutions with standards of 0.5, 1.0, 2.0, 5.0 ppm Cr_2O_3. The regression line was calculated by the following formula:

$$y = b_0 + b_1x$$

where,

y = measured atomic absorbance reading

b_0 = calculated y-intercept

b_1 = slope of the regression line

x = chromic oxide ppm

Chromium content in ppm was determined by the following formula (Ellis et al., 1982):

$$\frac{\dfrac{AA - b_0}{x}}{\text{dry sample weight}} * 100 \; / \; \%0M$$

where,

AA = measured atomic absorption for sample

b_0 = calculated y-intercept from standards

x = calculated slope from standards

dry sample weight = measured dry sample weight of individual sample

Milk Production

Milk production was measured using the weigh-suckle-weigh technique, as described by Williams et al. (1979). The separation interval was 6 hours for each lactation time. The technique was performed once at each point in lactation. All estimates of milk production were converted to a 24 hour basis.

Statistical Analysis

Data for calf weights (WT) were analyzed by period using least squares procedures (SAS, 1993). The statistical model included main effects for dam breed (DBRD), sire breed (SBRD), age of dam (AOD), year, calf sex (SEX) and age of calf (CAGE). All possible 2-way interactions between main effects. Least square means were obtained for DBRD, AOD, and SEX for all three periods.

Mean fecal output estimates by calf within period were analyzed (n=162) using least squares procedures (SAS, 1993). The statistical model included fixed main effects for breed of dam (DBRD), breed of sire (SBRD), age of dam (AOD), year, and calf sex (SEX), with all possible 2-way interactions tested. Covariates included calf day of age (CAGE), dam milk production, dam weight, and calf weight. Covariates were tested using backward elimination to drop unimportant (P>.10) covariates from the model. Non-significant covariates and interactions were removed and a reduced model was fit. Covariates used in the final model were CAGE for period I, and WT for periods II and III. Repeated measures were not used in the analysis because not all the same cows and calves were used in each of the periods within years.

CHAPTER 4

RESULTS AND DISCUSSION

Calf Traits

Calf Weight

Least squares analyses of variance for calf weight by period are presented in Table 4. Breed of dam was important (P<.05) for each period while breed of sire was only important in PI. There was a significant year effect for PI but not for PII and PIII. Year effects for PI may be explained by greater precipitation in 1993 (60.7 cm) than 1992 (40.5 cm). The higher levels of precipitation in 1993 may have allowed for a longer growing season and increased forage quality later into the summer grazing period. Male calves had greater (P<.05) weight during all periods. These results are consistent with reports of beef calves (Nevelle, 1962) and beef x dairy F_1 crossed calves on range (Bair et al., 1972) where it has been found male calves are generally heavier then heifer calves. Days of age (CAGE) was important (P<.05) as a covariate during each period. The regression of calf weight on days of age indicated calf weights increased approximately 1 kg for each 1 day increase in age. These results agree well with those reported by others working with the same population of cattle at the same location (Kress et al., 1996; Davis et al., 1998).

Table 4. Analyses of Variance for Calf Weight By Period (Pr>F)

Source	PI	PII	PIII
Dam Breed	.0230	.0034	.0001
Sire Breed	.0022	.2465	.4664
AOD	.0001	.0009	.0001
Year	.0453	.4808	.5045
Sex	.0005	.0098	.0004
CAGE	.0001	.0018	.0001
MS Error	102	288	220
CV	9.49	8.51	6.72
R^2	.68	.63	.77

Table 5 lists means for calf weight by breed of dam and age of dam (AOD) for each period. Calves from Tarentaise (TT) and Hereford x Tarentaise (HT) dams were heavier (P<.05) than calves from Hereford (HH) dams in PII and PIII, but not in PI. These results are consistent with the findings of Cundiff et al. (1981) who reported Tarentaise x Hereford and Tarentaise x Angus dams weaned heavier calves than Angus x Hereford and Hereford x Angus dams. Previous studies with the same population of cows (Hirsch et al., 1996; Kress et al., 1995; Kress et al., 1996) found TT and HT cows had greater milk production levels than the HH cows (Tables 15 and 16) and weaned heavier calves. Calves raised on TT dams have been found to be heavier and carry more condition than calves reared by HH at the same location (Davis et al., 1998). Tarentaise raised calves were 30 kg heavier than HH reared calves in PIII. Maternal breed effects have been reported for calves raised by TT dams by 120d of age (Kress et al., 1996) and TT dams weaned calves 26 kg heavier than HH dams in the same environment (Davis et al., 1998). These results are in general agreement with Wyatt et al. (1977), who reported a 20% increase in weaning weights for Angus x Hereford calves raised by high milk producing dams on range. Adams et al. (1993) reported calves in eastern Montana reared on high milk producing dams gained more weight to weaning than calves suckling low producing dams. Age of dam was important (P<.05) with calves from 2-and 3-yr-old cows being lighter than calves of 4-and 5-yr-olds in all periods except PI where 2-yr-old dams had lighter calves than all other age groups. These differences may be accounted for by AOD milk production differences. Two year old dams produced less (P<.05) milk (average = 5.4 kg) than 3- ,4- ,or 5+ - yr - old dams (Table 10). There were no significant differences in calf weights between 4 and 5+ -yr - old dams.

Table 5. Calf Weight (kg) for Breed of Dam and AOD by Period[a]

Breed[b]	PI	PII	PIII
TT	104 ± 2.2[c]	211 ± 7.4[c]	239 ± 6.8[c]
HT	108 ± 2.0[d]	210 ± 4.7[c]	228 ± 5.2[c]
HH	100 ± 2.2[c]	189 ± 4.4[d]	203 ± 5.4[d]
Age of Dam			
2	84 ± 3.1[c]	182 ± 7.8[c]	210 ± 7.7[c]
3	101 ± 2.6[d]	195 ± 4.8[c]	208 ± 5.1[c]
4	115 ± 2.5[e]	221 ± 7.9[d]	236 ± 8.0[d]
5	116 ± 2.1[e]	215 ± 5.8[d]	239 ± 6.3[d]

[a] Least-squares means ± SE.
[b] TT = Tarentaise; HT = Hereford x Tarentaise; HH = Hereford
[c,d,e] Means in same column with different superscript differ (P<.05).

Calf Fecal Output

Analyses of variance for calf fecal output by period are given in Table 6. Breed of dam approached significance (P=.07) during PI and was important (P<.05) in PIII, while breed of sire was not important (P>.05). Age of dam (AOD) was important (P<.05) during PIII. There was a significant year effect during PI and PII, but not for PIII. Fecal outputs were similar (P>.05) between calf sexes. Days of age were used as the covariate for PI, while calf weight was used for PII and PIII. Initial analyses included calf age and weight as covariates, but they were too highly correlated to be included at the same time. CAGE was used as the single covariate in PI because CAGE (average age = 76 d) accounted for more of the variation than weight. Milk intake has been shown to have a greater affect on calf performance through the first 2 months of age as compared to later stages of life (Melton et al., 1967). Weight was used in the model as a covariate for Period II and Period III because it accounted for more variation than CAGE and it has been reported that increases in forage intake may be more correlated to calf size and weight than calf age (Lusby et al., 1976). Boggs et al. (1980) reported calf performance to be negatively related to grass intake through the first 2 months of age, yet a positive correlation was found when calves were greater than 3 months old.

Table 6. Analyses of Variance for Calf Fecal Output by Period (Pr>F)

Source	PI	PII	PIII
Dam Breed	.0746	.6066	.0006
Sire Breed	.2778	.5820	.1791
AOD	.2598	.2966	.0057
Year	.0005	.0024	.2422
Sex	.7372	.7899	.9932
CAGE	.0001	-	-
WT	-	.3630	.0022
Milk	.3122	.0782	-
MS Error	15020	113853	490702
CV	25.56	21.67	32.43
R^2	.68	.51	.50

Table 7 lists calf FO means for breed of dam and AOD by period. Dam breed group differences were important during PI and PIII with calves from TT dams having less FO than calves from HT and HH dams. Fecal output increased from 0.48 kg in June to 1.56 kg by September. These results are in general agreement with those reported by Ansotegui et al. (1991). Daily dry matter fecal output estimates for Hereford x Angus calves grazing summer pasture comprised of 65% grasses and 35% forbs and shrubs in the Madison Range of Montana were between .24 and .49 kg/d in July and between .72 and 1.28 kg/d in September. They are also in general agreement with others who have reported increased forage intake from 44 days of age to weaning (Boggs et al., 1980; Bailey and Lawson 1981; Grings et al., 1997).

The differences in fecal output may partially be partially explained by differences in milk production by the dam breed groups. While milk production differences were not important (P>.05) for the population sampled used in this project, previous research with the population of cows which were sampled for this project found difference (Table 11) between milk production levels for Tarentaise and Hereford dams (Kress et al., 1996).

Table 7. Fecal Output (g) for Breed of Dam and AOD by Period[a]

Breed[b]	PI	PII	PIII
TT	426 ± 26.2[c]	1486 ± 153.6[c]	1193 ± 281.8[c]
HT	509 ± 23.4[d]	1552 ± 102.6[c]	2052 ± 200.1[d]
HH	487 ± 26.7[d]	1661 ± 93.2[c]	2960 ± 232.1[e]
Age of Dam			
2	520 ± 37.5[c]	1784 ± 133.1	2474 ± 294.1[c]
3	448 ± 30.9[c]	1544 ± 99.9	2746 ± 203.3[c]
4	437 ± 30.9[c]	1399 ± 181.5	1611 ± 313.9[d]
5	491 ± 25.2[c]	1538 ± 118.7	1443 ± 264.0[d]

[a] Least-squares means ± SE.
[b] TT = Tarentaise; HT = Hereford x Tarentaise; HH = Hereford.
[c,d,e] Means in same column with different superscript differ (P<.05).

Milk production of the dam has been shown to decrease in the latter stages of the milk production cycle (Davis et al., 1994) and from parturition to weaning (Holloway and Butts, 1983). Kress et al., (1996) reported Tarentaise dams maintained higher milk productions from 40d to 120d at the same location. In a study using cross fostered Angus x Hereford calves suckling high milking Friesian dams or low milking Hereford dams, Wyatt et al. (1977) reported lower forage intake levels for the Hereford x Angus calves suckling the high milk production dams. Calves with low milk intakes may partially compensate by increasing forage intake (Baker et al., 1976; Le Du et al., 1976; Boggs et al., 1980). In work with suckling Hereford x Angus calves grazing native range, Ansotegui et al. (1990) reported that with decreases in available milk, calves become more dependent upon forage. Sowell et al. (1996) reported young calves were not able to increase forage organic matter intake while grazing 77% NDF bluegrama range in New Mexico to compensate for decreased milk intake. Holloway et al. (1982) reported calves were unable to compensate for lower milk intakes by increases forage intake on fescue pastures.

Milk analyzed as a covariate was important during PII. An increase of 1 kg of milk intake during PII resulted in an increase of 26g of FO. It has been reported that milk consumption may increase forage utilization on low quality pastures (Holloway et al., 1983). The increases may be partially explained by milk providing additional protein which may promote better microbial use of low quality forages.

There were no significant difference (P>.05) in calf FO by AOD during P I. During PII calves of 2-, 3-, and 5-yr-old dams had greater FO than calves of 4-yr-olds. Calves of 2- and-3- yr-old dams had greater FO in PIII than calves from 4- and-5- yr-old dams.

Milk production by AOD was important for 2 yr old dams in the sample of cows used in this study (Table 10), work by Kress et al. (1996) reported age of dam differences for the same experimental cow herd. Data from the entire herd indicated 2 and 3-yr old dams produced less ($P<.05$) milk during periods I and II (Table 15). A possible explanation for difference in FO by AOD may be the calves suckling older dams and receiving more milk were less accustomed to grazing, and were therefore less efficient at grazing. Le Du et al. (1976) reported Hereford x Friesian crossed calves raised on a high verses low quantity of milk replacer had different levels of herbage intake. The calves raised with higher levels of milk replacement consumed less forage post weaning and it took a few weeks before their level of forage intake match that of the calves that received the low milk replacer levels.

The model accounted for 45-67% of the variation in fecal output. This would seem to suggest other factors not accounted for may be important variables when considering calf FO or forage intake as the calves become less dependent on milk and rely more heavily on forage to meet their nutritional requirements. It has been demonstrated that calves grazing late summer ranges of low quality forages had similar nutrient intakes as older steers, but during the mid summer months the calves selected a diet higher in crude protein and 14% less ADF then older steers (Grings et al., 1995). Holloway et al. (1985) noted pre-weaning Angus calves grazing fescue-legume pastures were able to compensate for lower milk intake levels as compared to calves on fescue pastures. The calves receiving lower levels of milk were able to compensate for the reduced milk intake by increasing forage intake. They found calves grazing fescue were more efficient at converting milk digestible energy to weight then the calves grazing fescue and legume mixed pasture. Additionally they reported an increase in the correlation of milk intake and weight gain and an increase in the correlation between forage intake and weight gain as the calves became older. They concluded calves on higher quality pastures and receiving lower levels of milk were able to compensate for the reduced milk intake by increasing forage intake.

Le Du et al., (1976) and Baker et al., (1976) have proposed herbage intake of milk fed calves is regulated by a metabolic rather than physical control system. They support the contention that herbage intake is controlled by an energy balance.

Fecal Output on Body Weight Basis

Analyses of variance for calf fecal output on a body weight basis are given in Table 8. Calf days of age was used as a covariate to account for calf age differences. Breed of dam was important (P<.05) for period III. Breed of sire was important during period I. Calves sired by Tarentaise bulls had greater (P<.05) fecal output per unit of body weight (g/kg) than calves sired by either Hereford or Hereford x Tarentaise bulls (Table 9). Year effects were important for PII.

Table 8. Analyses of variance for calf fecal output per unit of body weight (FOBW) by period (Pr>F)

Source	PI	PII	PIII
Dam Breed	.2179	.2677	.0014
Sire Breed	.0270	.5801	.2379
AOD	.0007	.1332	.0333
Year	.0003	.0003	.3554
Sex	.2468	.8639	.2563
CAGE	.0088	.6574	.2687
Milk	.4494	.1880	
MS Error	1.512	3.381	11.955
CV	26.91	23.27	34.74
R^2	.64	.50	.51

These results are in general agreement with those of Grings et al. (1997) comparing high growth to moderate growth potential calves determined by sire breed. These researchers reported there were differences in forage intake due to breed of sire, but no differences (P>.10) when the animals were compared on an organic matter intake per unit of body weight basis. It was suggested the differences found in forage intake where related to increases in body weight for the high growth potential sired calves. Age of calf was important during period I, and age of dam differences were detected for periods I and III.

Table 9. Fecal output per unit of body weight (g/kg/d) for breed of sire, breed of Dam and AOD by period

Breed of Sire[b]	PI	PII	PIII
TT	4.77 ± .23[a]	7.58 ± 0.59[a]	10.97 ± 1.17[a]
HT	5.09 ± .32[b]	8.42 ± 0.71[a]	9.37 ± 1.05[a]
HH	4.02 ± .23[b]	7.61 ± 0.51[a]	8.32 ± 1.03[a]
Breed of Dam[b]	**PI**	**PII**	**PIII**
TT	4.25 ± 0.26[a]	7.29 ± 0.82[a]	6.26 ± 1.27[a]
HT	4.69 ± 0.24[a]	7.71 ± 0.52[a]	9.65 ± 0.95[b]
HH	4.93 ± 0.27[a]	8.60 ± 0.49[a]	12.75 ± 1.00[c]
Age of Dam			
2	5.96 ± .38[a]	9.28 ± 0.86[a]	9.43 ± 1.83[a b]
3	4.48 ± .31[b]	7.88 ± 0.53[a]	12.2 ± 0.95[a]
4	3.85 ± .31[b]	6.45 ± 0.88[a]	8.42 ± 1.46[b]
5+	4.23 ± .25[b]	7.87 ± 0.63[a]	8.14 ± 1.19[b]

[a] TT = Tarentaise; HT = Hereford x Tarentaise; HH = Hereford.
[b,c,d] Means in same column with different superscript differ (P<.05)

Fecal output by breed of dam differed (P<.05) during PIII. Hereford reared calves had greater (P<.05) FO levels than calves reared by HT or TT dams. Calves raised by

HT dams had considerably more (P<.05) FO than calves of TT dams. Results from analyses of FOBW basis agree with the FO results. Fecal output on a body weight basis has been suggested as a means to remove variation in the data due to different weights of the calves (Mertins, 1994). The calves from HH dams had approximately twice the FO levels as compared to the TT raised calves suggesting they were consuming more forage 2 weeks post weaning. These results are similar to those of others who have reported that through the first 8 wks post weaning calves receiving higher milk levels did not consume as much forage as calves which weaned from lower milk levels (Kaiser, 1983).

Other possible reasons for these differences may be that calves of TT dams were less experienced at grazing to meet their nutritional requirements and that their rumens may not have been as developed as the HH reared calves due to lower forage intakes pre-weaning.

Milk Analysis

Data was analyzed for milk production collected during PI and PII with main effects of breed of dam, breed of sire, age of dam, sex of calf, year, and calf age as a covariate. Table 10 list analysis of variance for milk production. During PI there were no differences observed for the main effects. During PII only year approached significance (P=.075). A lack of dam breed importance may be due to small cow numbers.

Least squares means are listed in Table 11 for milk by breed of dam and age of dam.

Table 10. Analysis of Variance for Milk Production

	PI	PII
Breed of Dam	.1291	.9965
Breed of Sire	.5546	.5251
AOD	.7595	.4184
Sex	.7806	.4276
Year	.5793	.0752
CAGE	.1783	.1780
CV	33.0	61.97
R^2	.13	.25

Table 11. Milk Production (kg) by Breed of Dam and Age of Dam

Breed of Dam	PI	PII
TT	14.3 ± 0.96^a	7.8 ± 1.99
HT	14.1 ± 0.88^a	7.54 ± 1.23
HH	11.8 ± 0.98^a	6.49 ± 1.19
Age of Dam		
2	13.1 ± 1.4^a	7.61 ± 2.1
3	13.1 ± 1.1^b	5.98 ± 1.2
4	13.0 ± 1.1^c	6.55 ± 2.1
5+	14.3 ± 0.9^c	9.17 ± 1.5

[a] TT = Tarentaise; HT = Hereford x Tarentaise; HH = Hereford.
[a, b, c,] Means in same column with different superscript differ (P<.05)

Table 12 lists regression analyses for measured values of FO on measured values of milk. Table 13 lists regression analyses for the residuals of FO on the residuals of milk.

In an attempt to determine if there were trends in FO verses milk, residuals of the full models for both FO and milk were plotted against one another. It was expected that if a linear relationship existed, that we had been unable to determine with an analysis of variance, than perhaps by plotting the residuals we could determine a general trend in the data. From the analysis of the FO data and the belief that a portion of the differences could be accounted for by differences in milk intakes, we would have expected to observe higher FO residuals or more variation in the FO residuals for low milk residuals and low FO residuals for high milk residuals.

The regression of FO on milk was important (P<.05) in PI with HT accounting for most of the trend. This may be misleading though, because it appears two observations are outliers and with the small number of observations they seem to be affecting the results. The same trend appears during PII for the HT. During PI there is a positive linear trend (P<.05) in the relationship of FO on milk for HH (Table 12). This plot appears to show there is more variation in FO at low milk levels than at high milk level.

Table 12. Regression (g/kg) of FO on milk

Breed	PI	PII
Combined	-9.7 (.05)[a]	37.4 (.009)
TT	-	18.8 (.48)
HT	-5.9 (.53)	26.5 (.003)
HH	-21.8 (.04)	-2.9 (.83)

[a] P – value for regression

Table 13. Regressions (Pr>F) of FO residuals on milk residuals (g/d)

Breed	PI	PII
Combined	.2806 (.01)[a]	.0129(.15)
TT	.3251 (.04)	.4642 (.11)
HT	.9976 (.00)	.0005 (.62)
HH	.3211 (.04)	.8854 (.001)

[a] R^2 of regression

Individual regression analyses on milk by breeds of dam (Table 12) did not result in expected trends. Plots for both the residuals (Figs 2, 4, 6, 8, 10, 12, 14, 16) and measured values (Figs 1, 3, 5, 7, 9, 11, 13, 15) appear to be randomly scattered without any visible. linear trend