Liquid supplementation of grazing cows and calves
by Allison Virginia Earley

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

Montana State University

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Abstract:

One hundred one Angus cows (612 kg) and their bull calves (214 kg) grazing improved summer pastures were used to determine cow and calf intake of liquid supplement, and its effect on forage intake and performance. Forty-seven pairs had access to liquid supplement in an open tank and 54 pairs were not supplemented. The study was conducted in southwestern Montana from July 28, 1997 to October 3, 1997. Ytterbium chloride was added to the liquid supplement (41 % CP, DM basis) to estimate individual supplement intake. Forage intake was estimated for all supplemented pairs and 10 unsupplemented pairs using estimates of fecal output obtained using chromium boluses and in situ 48 h DM digestibility. All supplemented cows and calves were fitted with a radio frequency (RF) eartag in order to electronically record each visit by an animal to the supplement feeder. Estimated supplement intake by cows and calves averaged .3 kg/d and .1 kg/d, respectively. There was no difference ($P > .10$) in supplement intake between cows and calves, averaging .04 % BW. Supplemented cows gained .12 kg/d more ($P = .02$) than unsupplemented cows; however, there was no difference ($P > .10$) in body condition score change between treatments. Average daily gain by supplemented calves was 30 % greater ($P < .01$) than ADG by unsupplemented calves. Forage intake (% BW) by supplemented cows and calves was 65 % greater ($P < .05$) than forage intake by unsupplemented cattle. There was no difference ($P > .10$) in time spent at the tank between cows and calves, averaging 4.9 min/d. Minutes per day at the feeder was lowest for 7-yr-old cows, intermediate for 6- and 8-yr-old cows, and highest for 9-yr-old cows ($P < .10$). There was no difference ($P > .10$) in bouts/d between age groups of cows. Calf use of liquid supplement was similar to use by cows. Liquid supplementation increased forage intake and ADG of cows and calves grazing improved forages in late summer. Time at the tank was not a good predictor of supplement intake, but could be used to rank supplement consumption by cows and calves.

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APPROVAL

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

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Signature Allison V. Early

Date August 28, 1998

This thesis is dedicated to my two grandfathers:

W. Edwin Jacobs,
who I think would appreciate this endeavor more than anyone else;

and

William C. Earley,
who let us help work his cattle.

Thank you both.

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ABSTRACT

One hundred one Angus cows (612 kg) and their bull calves (214 kg) grazing improved summer pastures were used to determine cow and calf intake of liquid supplement, and its effect on forage intake and performance. Forty-seven pairs had access to liquid supplement in an open tank and 54 pairs were not supplemented. The study was conducted in southwestern Montana from July 28, 1997 to October 3, 1997. Ytterbium chloride was added to the liquid supplement (41 % CP, DM basis) to estimate individual supplement intake. Forage intake was estimated for all supplemented pairs and 10 unsupplemented pairs using estimates of fecal output obtained using chromium boluses and *in situ* 48 h DM digestibility. All supplemented cows and calves were fitted with a radio frequency (RF) eartag in order to electronically record each visit by an animal to the supplement feeder. Estimated supplement intake by cows and calves averaged .3 kg/d and .1 kg/d, respectively. There was no difference ($P > .10$) in supplement intake between cows and calves, averaging .04 % BW. Supplemented cows gained .12 kg/d more ($P = .02$) than unsupplemented cows; however, there was no difference ($P > .10$) in body condition score change between treatments. Average daily gain by supplemented calves was 30 % greater ($P < .01$) than ADG by unsupplemented calves. Forage intake (% BW) by supplemented cows and calves was 65 % greater ($P < .05$) than forage intake by unsupplemented cattle. There was no difference ($P > .10$) in time spent at the tank between cows and calves, averaging 4.9 min/d. Minutes per day at the feeder was lowest for 7-yr-old cows, intermediate for 6- and 8-yr-old cows, and highest for 9-yr-old cows ($P < .10$). There was no difference ($P > .10$) in bouts/d between age groups of cows. Calf use of liquid supplement was similar to use by cows. Liquid supplementation increased forage intake and ADG of cows and calves grazing improved forages in late summer. Time at the tank was not a good predictor of supplement intake, but could be used to rank supplement consumption by cows and calves.

INTRODUCTION

Agriculture is the leading industry in Montana with cash receipts totaling over two billion dollars (Mont. Ag. Stat. Serv., 1997). Cash receipts from the sale of cattle and calves account for 32% of all commodities sold in Montana (Mont. Ag. Stat. Serv., 1997). Lindholm and Stonaker (1957) reported that calf weaning weight (WW) is the most important trait affecting net income of cow/calf operations.

Nutrition is an important aspect of both cow and calf performance and it is estimated that feed costs account for 60 to 70% of a producers total expenditures (USDA, 1994). Sixty-six percent of the land in Montana farms and ranches is classified as rangeland or pasture (Mont. Ag. Stat. Serv., 1997) and most cow/calf producers utilize these rangelands to decrease production costs. However, the quantity and quality of forage available on rangelands can be limiting during certain times of the year and supplementation may be required to optimize cow and calf performance. Forage quality decreases through the summer as plants mature and lactating cows grazing rangelands may be energy and protein deficient from August through October (Adams and Short, 1988). This period of reduced forage quality also corresponds to the period of increased reliance on forage by the calf due to declining milk production of the cow. When forage quality decreases, it may be profitable to supplement animals to increase forage intake and supply animals with limiting nutrients in order to improve performance. Wagon (1965) suggested it is more efficient to promote weight gains of cows during this period than to promote weight gains by cows during the winter months.

Liquid supplements provide a source of energy and protein to the ruminant and can be self-fed which reduces labor costs (Grelen and Pearson, 1977). Several researchers have reported increased weaning weights and ADG for calves of liquid supplemented cow/calf pairs (Grelen and Pearson, 1977; Hennessy, 1986; Bowman et al., 1994). There is very little data reporting calf use of supplements and it is not known if these calves performed better due to higher milk intakes or calf use of the supplement.

The objectives of this study were to determine the level of supplement intake and use by cows and calves with access to liquid supplement in an open tank; and to determine the effects of liquid supplementation on cow and calf performance, forage intake, forage digestibility and cow milk production.

LITERATURE REVIEW

Factors Influencing Calf Performance

Lindholm and Stonaker (1957) reported that calf weaning weight (WW) is the most important trait affecting net income of cow/calf operations. Average daily gain (ADG) and weaning weight (WW) are measures of calf performance and can be influenced by a variety of genetic and nutritional factors.

Supplementation

Grazing animals are supplemented with energy or protein in order to improve energy balance during certain times of the year; however, animal response to supplementation can be influenced by the type of supplement provided. Energy supplements are less expensive than protein supplements, but animal responses to energy supplementation have been inconsistent (Horn and McCollum, 1987). Perry et al. (1991) reported lower levels of energy available to the cow pre- and post-partum resulted in decreased milk production and lower calf weights at 70 d. Bellows and Thomas (1976) reported no improvement in calf gains from grain supplementation of cows before and during the breeding season. Furr and Nelson (1964) reported that creep-fed calves were 39 kg heavier at weaning than non-creep-fed calves. Lack of cow response to energy supplementation could be due to decreased forage intake observed with energy supplementation (Bellows and Thomas, 1976; Kartchner, 1981). Higher starch intakes decrease rumen pH, which inhibits fiber digestion (Horn and McCollum, 1987).

Protein supplements are more expensive, but the effect on performance is less variable (Adams, 1985). Wallace (1988) reported that protein was the first limiting

nutrient in diets of cattle grazing dormant forage and that cattle responded better to protein than grain supplements. Kartchner (1981) reported higher forage intakes by cows consuming low quality forages with protein supplementation. Protein increases forage intake by stimulating microbial growth, thereby increasing digestion and rate of passage (Coleman and Wyatt, 1982; McCollum and Galyean, 1985; Petersen, 1987). Dhuyvetter (1991) reported increased gains for calves of 3-yr-old cows supplemented with protein pre- and postpartum; however, supplementation did not influence milk production of the cow. Wallace (1988) also reported higher WW for calves of mature cows supplemented with protein in late gestation.

Liquid supplements provide a source of energy and protein to the ruminant and can be self-fed which reduces labor costs (Grelen and Pearson, 1977) and decreases interference with normal grazing behavior. Pate et al. (1990) reported improvements in calf performance by calves of 3-yr-old cows that were offered liquid supplement; however, Landblom and Nelson (1990) found no difference in gains of calves with access to a molasses feedblock. Grelen and Pearson (1977) reported that calves of cows on a year-round liquid supplementation program had 7 kg higher WW than calves of cows who received cottonseed cake only during the winter. Hennessy (1986) reported 20% higher WW for calves receiving a cottonseed meal or molasses/cottonseed meal mix compared to unsupplemented calves. He attributed this increase in WW to increased milk production of the cow. Bowman et al. (1994) provided 2 yr old cows with liquid supplement offered in an open tank for 2 1/2 months post-partum. During the supplementation period, calves of supplemented cows had 15.5 % greater ADG than calves of unsupplemented animals. These researchers wondered if supplemented calves performed better due to higher milk intakes or if calves consumed liquid supplement.

There are very few studies that have collected supplement and milk intake data from calves of supplemented cows.

Forage quality as well as the type of supplement offered can influence animal response to supplementation. Langlands and Donald (1978) found that yearling heifers responded to supplementation when grazing native range but not improved pastures. Butterworth et al. (1973) reported that supplementation was more effective in the winter when forage availability was lowest, than in the spring when more forage was available. Jones (1966) reported that weight loss was reduced when cattle were grazing lower quality pastures and offered a molasses-urea feedblock.

In a review of liquid supplemented ruminants consuming low quality forages, Bowman et al. (1995b) concluded that performance and forage intake by supplemented animals were confounded by pasture condition, forage quality, animal variation and supplement delivery system. These authors noted that forage intake and gains by unsupplemented cattle were related to CP content of the forage. Langlands and Donald (1978) reported increased weight gains by supplemented animals when the CP content of the forage was less than 10 %. Moore et al. (1995) compiled data from 51 studies and concluded that animal response to supplementation (dry or liquid) depends on the ratio of digestible organic matter (DOM) to CP content of the forage. When the DOM:CP is greater than 7, supplementation will increase animal weight gains and forage intake. However, when the DOM:CP is less than 7, weight gains could be increased but there was generally a decrease in forage intake. Emanuele (1997) reviewed the use of molasses supplements in dairy rations and concluded that the readily digestible sugars provided by these supplements will not decrease rumen pH or inhibit fiber digestion when they make up less than 15 % of the ration on a DM basis. He also noted that animal response is greater when the ration contains adequate amounts of rumen degradable

amino acids and peptides. Bowman et al. (1995a) reported a 47 % increase in forage intake and 36 % increase in DM digestibility by liquid supplemented cows grazing native fall range (8 % CP, 72 % NDF). Daniels et al. (1998) also reported 47 % greater forage intakes and 25 – 59 % higher DM digestibility by liquid supplemented cows grazing native winter range (5 % CP, 79 % NDF).

Forage Intake

Plane of nutrition available to the calf other than milk can influence calf growth (Neville, 1962). Forcherio et al. (1995) related increased calf gains to greater milk production by the cow and slightly greater forage intake by the calf. Peischel (1980) reported that forage consumed by the calf had a positive effect on calf weaning weight. Boggs et al. (1980) concluded that grass intake was negatively related to ADG in the first 2 months of life and poorly related to calf performance over the entire pre-weaning period. However, he also reported that added grass intake did improve gain in the third, fourth, and fifth months of the calf's life.

Some researchers have documented the relationship between milk intake and forage intake by calves. Baker et al. (1976), Le Du et al., (1976a, 1976b), and Le Du and Baker (1979) reported an inverse relationship between calf milk intake and forage OM intake. Broesder et al. (1990) reported that reducing the amount of milk replacer fed to calves resulted in an increase in OM intake of alfalfa hay; however, total OM intake remained constant among milk reduction groups. Boggs et al. (1980), Clutter and Nielson (1987) and Ansotegui et al. (1991) reported that calves increased forage intake to make up for decreased milk production, but Peischel (1980) and Sowell et al. (1996) reported different findings.

Milk Production

Rutledge et al. (1971) reported that milk production, calving date, age of dam, calf birth weight, cow weight, year, sire and calf sex accounted for 92.4% of the variation in calf weight at 205 days. They concluded that milk production was the single most important factor in the equation, accounting for 60 % of the variation in 205-d calf weight. Neville (1962) included the same variables in his regression model and reported that they accounted for 82% of the variation in 120- and 240-d weights, and 240-d gains; with milk production accounting for 66% of the variation in calf weight at 240-days. Furr and Nelson (1964) reported that milk production accounted for 66 to 72 % of the variation in ADG; however, correlation estimates between average daily gain and milk yield decreased as lactation progressed. Neville (1962) and Rutledge et al. (1971) also reported that the correlation between milk intake and calf ADG decreased as lactation progressed. Kress and Anderson (1974) reported correlation estimates between cow milk production and calf ADG of .50 early in lactation, which decreased to .18 near weaning. Melton et al. (1967) reported that ADG and milk production were only significantly correlated in the first 77 d of lactation, and that the correlation between ADG and milk production declined as lactation progressed (.58 to .03). Neville (1962) concluded that cow milk production is most important in the first 60 days of a calf's life. This time period corresponds to the time of peak milk production by the cow (Totusek et al., 1973; Kress and Anderson, 1974; Williams et al., 1979; Casebolt et al., 1983; Bushkirk et al., 1992). Weight of dam (Rutledge et al., 1971; Urick et al., 1971) and age of dam (Neville, 1962; Havstad et al., 1989) can influence calf WW, primarily through the amount of milk they produce (Neville, 1962; Rutledge et al., 1971).

Estimating Supplement Intake

Lack of data regarding individual intake of supplements makes it difficult to interpret effects of supplementation on individual animal performance in grazing trials (Nolan et al., 1974). Inconsistencies in performance of liquid supplemented animals could be a result of the wide variation in individual animal intakes (Sowell et al., 1995).

Nolan et al. (1975) used tritiated water to estimate individual animal intake of a urea-molasses supplement by 200 grazing sheep. Ninety-seven of the sheep were classified as nonconsumers and individual intake by consumers ranged from 5 to 550 ml/d. Sheep consuming supplement lost less weight and showed increased wool growth compared to nonconsuming animals. Lobato et al. (1980) estimated individual intakes of supplemental oats, hay and a molasses block by grazing sheep using chromic oxide as a marker. Eight of 15 sheep did not consume any of the molasses block. There was a positive correlation between liveweight gain and individual intake of oats and hay, but not the molasses block (Lobato et al., 1980). Mulholland and Coombe (1979) reported a 40 % coefficient of variation (CV) in individual supplement intake by grazing wethers supplemented with urea, molasses and minerals, and only two animals were classified as nonconsumers. These researchers did not find a strong relationship between supplement intake and rate of liveweight change.

Nolan et al. (1974) estimated individual supplement intake using isotope labeling and reported that 8 of 48 heifers refused to consume liquid supplement. Individual animal intakes ranged from 30 ml to 2.4 L/d; and rate of liveweight change was significantly correlated with supplement intake. Langlands and Donald (1978) used tritiated water to estimate individual intake of a molasses supplement by seven grazing heifers and steers. Four percent of the animals refused to consume supplement and the CV between individual intakes was 37 %. One would assume that the variability of

larger herds of cattle under increased stocking rates would be greater. Llewelyn et al. (1978) used the tritiated water marker method to estimate individual supplement consumption of 37 pregnant heifers grazing a 223 ha paddock. Intakes ranged from 0 to 2.6 kg/d with 62 % of the animals consuming some supplement. Rate of liveweight loss was reduced by supplementation (Llewelyn et al., 1978)

Curtis et al. (1994) used ytterbium (Yb) as a marker to estimate supplement intake by grazing sheep. These authors reported that the mean retention time of Yb was not affected by diet and that the concentration of Yb in fecal grab samples could be used to rank individual supplement intakes. They suggested using Yb with a second marker such as chromic oxide to estimate fecal output. Gibson et al. (1995) evaluated the use of chromic oxide continuous release boluses to estimate fecal output and Yb marked liquid supplement to estimate supplement intake. The technique overestimated liquid supplement intake by 10%, but there was a linear relationship ($P < .001$; $R^2 = .92$) between actual supplement intake and predicted supplement intake (Gibson et al., 1995). Bowman et al. (1995a) used the method of Gibson et al. (1995) to estimate liquid supplement intake by 60 cows grazing fall native range and reported supplement intake by individual animals ranged from .002 to 2.54 kg/d. Twenty-nine percent of the animals consumed only trace amounts of supplement.

Estimating Forage Intake

Measuring forage intake under range conditions presents many challenges. It is impossible to directly measure forage intake by grazing animals; however, it can be calculated indirectly by dividing fecal output by the indigestibility of the forage.

The best measurement of fecal output is obtained through total fecal collections using fecal bags, but under range conditions the bags can fall off, tear, or alter grazing

behavior due to numerous collection times. Fecal output by grazing animals can be estimated using external markers as reviewed by Pond et al. (1987). Chromic oxide (Cr_2O_3) is the most commonly used external marker for estimating fecal output because it is easy to analyze, relatively inexpensive and is available in a continuous release bolus (Paterson and Kerley, 1987). Chromic oxide is not associated with either the liquid or particulate phase of rumen digesta and traditionally has been dosed for several days in order to achieve steady state conditions of excretion (Pond et al., 1987). However, Laby et al. (1984) developed a continuous release chromic oxide bolus that eliminated the need for several dosings making it more practical for use under grazing conditions. The continuous release bolus increases the flexibility of fecal sampling routines and further reduces animal handling requirements (Parker et al., 1990). Furnival et al. (1990) reported that in sheep, the continuous release chromium bolus produced more reliable estimates of fecal output than twice daily dosings of chromic oxide in gelatin capsules. Diurnal variation in excretion is removed with the continuous release bolus so that the remaining variability is more closely associated with patterns of feed intake and digesta flow (Laby et al., 1984; Furnival et al., 1990; Parker et al., 1990; Momont et al., 1994). Chromic oxide excretion plateaus 5 to 6 days after bolusing (Laby et al., 1984) and the optimum window of chromic oxide excretion occurs between 6 and 14 days post-dosing (Kattnig et al., 1990). Hollingsworth et al. (1995) and Momont et al. (1994) also reported that estimates of fecal output were not influenced by supplemental treatments. There are no chromic oxide boluses specifically designed for use in calves; however, Swensson et al. (1995) reported that one sheep continuous release boluses could be used to estimate fecal output in grazing calves weighing less than 150 kg.

Forage digestibility can be estimated using internal markers (Cochran et al., 1987), *in situ* (Bowman et al., 1995a) or *in vitro* techniques (Tilley and Terry, 1963).

Internal markers can be used to estimate digestibility for each individual animal (Cochran et al., 1987); however, *in situ* and *in vitro* techniques give a more direct estimate of digestibility. *In vitro* lab analysis does not always give an accurate estimate of digestibility of the forage, but *in situ* estimates obtained from a few animals may not be representative of the entire herd (Parker et al., 1991). Peischel (1980) and Ansotegui (1986) reported that the rumen kinetics of suckling calves is similar to that of mature cows. Peischel (1980) reported that calves selected diets higher in protein than mature cows throughout the season; however, Grings et al. (1995) found that suckling calves selected higher quality diets only earlier in the summer when they received most of their nutrients from milk.

Mayes et al. (1986) reported that forage intake could be estimated without the need to estimate fecal output or forage digestibility using plant n-alkanes as markers. Dove and Mayes (1991) reviewed the use of plant alkanes as markers to estimate forage intake and digestibility of individual animals. Forage intake can be estimated using a pair of alkanes, one dosed (artificial, even-chained) and one natural (odd-chained), if they have similar fecal recoveries. The n-alkanes C₃₂ and C₃₃ fit this criteria. The C₃₆ alkane is relatively indigestible and can be used to estimate digestibility. Satisfactory results have been obtained using this method (Mayes et al., 1986; Dove and Mayes, 1991), but results have been more variable in cattle than in sheep. Most of the work with cattle has been done in confinement and diurnal variation in excretion patterns can be a problem. The alkanes are available as continuous release boluses for three sizes of animals; however, they are 50 % more expensive than the chromic oxide boluses and the lab analysis of alkanes in forage and feces is more laborious than that of chromium. In addition, samples must be freeze-dried and not oven-dried for analysis. Different plants have different amounts of alkanes and a good sample of forage grazing animals are selecting is critical

for obtaining accurate estimates of intake and digestibility. Most of the research conducted using alkanes has been done in Australia and few researchers in the United States have reported results using this technique.

Estimating Milk Intake

Milk production by the cow is influenced by breed and level of nutrition (Kress and Anderson, 1974; Casebolt et al., 1983), and its measure corresponds to milk intake by the calf. Milk production or calf milk intake has been estimated using weigh-suckle-weigh techniques (Lam et al., 1970; Kress and Anderson, 1974; Williams et al., 1979), tritiated water (MacFarlane et al., 1969), portable milking systems with oxytocin injections (Beal et al., 1990), and hand-milking (Totusek et al., 1973). Lam et al. (1970) compared three weigh-suckle-weigh techniques and reported that all three methods gave comparable rankings of milk production and were equally reliable. Beal et al. (1990) found that repeatability of milk production estimates using a portable milking system and oxytocin injections was higher than repeatability of estimates obtained from weigh-suckle-weigh methods. Other researchers found that hand-milking underestimated milk yield and that weigh-suckle-weigh estimates were a more accurate estimate of the amount of milk consumed by the calf (Totusek et al., 1973). Williams et al. (1977) determined that the average separation time of calves nursing in their natural environment was 4.5 h and that calves nursed 3.2 to 3.5 times per day in mid-spring. Williams et al. (1979) suggested that 8 h separation intervals gave the best estimate of milk production when using weigh-suckle-weigh techniques. Sowell et al. (1996) reported that the number of times calves suckle per day decreased as calves' aged and that they suckled 2 to 2.5 times per day in August and September.

Behavior of Supplemented Animals

Wagnon (1965) suggested that variation in individual supplement consumption may be influenced by differences in social dominance of individual animals. This may result in varying weight gains of supplemented cattle. Wagnon (1965) collected behavior data of a mixed-age group of Hereford cattle (2 to 10 yr) using visually recorded observations. Cattle were called to the supplement feeding area and hand-fed. He reported that older cows tended to have a higher social dominance ranking (peaking at age 9) and that 2-yr-old cows were generally driven away from the supplement by older animals. However, when 2-yr-olds were removed from the herd, the 3-yr-olds were now chased away by the older cows. Two and three year old cows gained more weight when they were managed separately from the rest of the herd. Heavier weights were also associated with social dominance, while aggressiveness and agility were used as tools, but did not necessarily dictate social dominance (Wagnon, 1965). Lower ranking cows tended to visit the feeder when there was less competition. Wagnon (1965) also reported that cows missing an occasional day were 7, 8 and 10-year-old cows, or those of mid to higher social rank; however, the percent refusing to eat was probably not different between age groups. Wagnon et al. (1966) reported that in a herd of 4-yr-old cows, social dominance was associated with breed, and there was a positive correlation between social dominance and size within breeds. Friend and Polan (1974) reported that there was a quadratic relationship between average time spent eating and social rank so that mid-ranked cows spent the least amount of time eating.

Sowell et al. (1995) recorded visual observations of animals using self-fed liquid supplement tanks, and reported that 2-yr-old cows visited the feeder less often and spent less time at the tank than 3-yr-old cows. They also noted that two out of 40 cows never

came to the supplement tank and that time at the tank ranged from 0 to 254 minutes in eight observation days. Bowman et al. (1995a) reported that 3-yr-old cows consumed more supplement than 2-yr-olds when cattle had access to liquid supplement in an unrestricted lick tank. However, supplement intake between 2- and 3-yr-old cows was similar when supplement was dispensed in a computer controlled lick tank that delivered a set amount of supplement every hour. Daniels et al. (1998) provided 2 to 6-yr-old cows grazing native range pastures with access to liquid supplement during the winter. Supplement intake was lowest for 2-yr-old cows, intermediate for 3-yr-old cows and highest for 4-, 5-, and 6-yr-old cows.

Lobato et al. (1980) noted that intake of hay and oats by sheep was also influenced by social dominance. Lobato and Pearce (1980) measured the number of sheep using supplement by placing a plastic sponge soaked in colored paste in the sides of the crate containing the supplement block. Eighty-six, eighty-nine and ninety-six percent of the groups had licked the blocks by the end of 1, 2, and 3 weeks, respectively.

Visual observations are labor and time intensive and other researchers have used electronic radio frequency equipment to study animal behavior. Basarab et al. (1996) and Sowell et al. (1998) used radio frequency equipment to monitor feeding and watering behavior of cattle in a feedlot. Putnam et al. (1968) reported that time at the feedbunk was associated with the amount of feed consumed. Tait and Fisher (1996) used electronic equipment to estimate use of a molasses feed block by individual grazing animals. A molasses feed block was placed on an electronic scale in a 4 ha pasture grazed by 20 yearling Holstein steers. All steers consumed the blocks and individual intake ranged from .72 to 1.65 kg/d (Tait and Fisher, 1996). Bailey (1976) reported that bull calves grazing a 32 ha pasture consumed a salt supplement offered in a creep feeder; however, these researchers did not estimate use or intake by individual animals. Cockwill et al.

(1998) recorded attendance at a mineral feeder by grazing cows and calves using a radio frequency technology. Percentages of cows and calves attending the mineral feeder depended on the formulation of the mineral supplement, and ranged from 26 to 97 % with fewer calves than cows attending the feeder.

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PERFORMANCE, FORAGE AND SUPPLEMENT INTAKE BY GRAZING COWS AND CALVES

Summary

One hundred one Angus cows (612 kg) and their bull calves (214 kg) grazing improved summer pastures, were used to determine cow and calf intake of liquid supplement, and its effect on forage intake and performance. Forty-seven pairs had access to liquid supplement in an open tank and 54 pairs were not supplemented. The study was conducted in southwestern Montana from July 28, 1997 to October 3, 1997. Ytterbium chloride was added to the liquid supplement (41 % CP, DM basis) to estimate individual supplement intake. All supplemented animals and 10 unsupplemented pairs were dosed with sustained release chromium boluses to estimate fecal output (FO). Extrusa samples were collected using ruminally cannulated cows and were incubated in situ for 48 h to determine DM digestibility. Forage intake was calculated using estimates of FO and 48 h DM digestibility. Individual forage and supplement intakes were estimated and analyzed using individual animal as the experimental unit. Supplement intake by cows averaged .5 kg/d (as-fed) and ranged from 0 to 2.2 kg/d (96 % CV). Supplement intake by calves ranged from .1 to .5 kg/d (81 % CV) and averaged .2 kg/d (as-fed). Supplement intake, when expressed as a % BW, was not different ($P > .10$) between cows and calves, averaging .04 % BW. Supplemented cows gained .12 kg/d more ($P = .02$) than unsupplemented cows and were 9 kg heavier ($P = .02$) at weaning. Change in body condition score was not different between treatments ($P > .10$).

Supplemented calves had higher ($P < .01$) WW, 205-d adjusted WW, and ADG than unsupplemented calves (299 vs 282 kg WW, 279 vs 267 kg adj. WW, and 1.3 vs 1.0 kg/d ADG). Forage intake by supplemented cows and calves was 64 % greater ($P < .01$) than forage intake by unsupplemented cattle (3.6 vs 2.2 % BW for cows and 2.8 vs 1.7 % BW for calves). There was no difference ($P > .10$) in calf milk intake estimates between treatments. Liquid supplementation increased forage intake and ADG of cows and calves grazing improved forages in late summer.

Introduction

Nutrition is an important aspect of both cow and calf performance and it is estimated that feed costs account for 60 to 70 % of a producers total expenditures (USDA, 1994). Sixty-six percent of the land in Montana farms and ranches is classified as rangeland or pasture (Mont. Ag. Stat. Serv., 1997), and most cow/calf producers utilize rangelands or pastures to decrease production costs. However, the quality and quantity of forage available to grazing animals can be limiting during certain times of the year, and supplementation may be required to optimize performance of grazing animals. An estimated 25 % of cattle in most western states are supplemented during the summer months (USDA, 1994), but these additional supplementation costs affect profitability. Liquid supplements can be self-fed which reduces labor costs (Grelen and Pearson, 1977). Liquid supplementation also increases forage intake and digestibility of native range (Bowman et al., 1995a; Daniels et al., 1998).

Profitability for the cow/calf producer can be increased by improving calf performance (Lindholm and Stonaker, 1957). Bowman et al. (1994) supplied primiparous 2-yr-old cows with liquid supplement for 2 ½ months postpartum and reported calves of supplemented cows gained 15.5% more than calves of cows receiving no supplementation. However, by weaning, there was no difference in calf weights between treatments. It is not known if calves of the supplemented cows performed better during the supplementation period due to increased milk production of the cow or if calves consumed liquid supplement. I could not find any published data reporting the use of liquid supplements by suckling calves. Estimates of individual supplement consumption make it easier to interpret effects of liquid supplementation on animal performance. The objectives of this study were to determine if calves consume liquid supplement directly, and to evaluate the relationship between cow and calf supplement intake and calf performance.

Materials and Methods

The study was conducted on a ranch in southwestern Montana from July 28, 1997 to October 3, 1997. Forty-seven Angus cows (age 6-9 yr) and their bull calves had access to a commercially available liquid supplement (Nutra-Lix, Inc., Billings, MT¹) in an open tank (Supp) and 54 pairs (cow age 3-5 yr) were unsupplemented (Unsupp). The supplement was 22 % CP on an as-fed basis (43.5 % of the CP from urea, as-fed) and 41 % CP on a DM basis. Cattle grazed improved irrigated pastures throughout the study. The Supp group was rotated three times between two different pastures, and the Unsupp

¹ This work was supported in part by Nutra-Lix, Inc., Billings, MT

group grazed three different pastures during the study (Figure 1). Both treatment groups remained on the same pasture during the intake sampling period (August 13 – August 29). Ten frames ($1/4 \text{ m}^2$) per pasture were hand-clipped at the beginning and end of each pasture rotation in order to estimate forage production and quality of the pastures. Hand-clipped samples were also obtained at the end of the intake sampling period (August 30). Pastures were dominated by intermediate wheatgrass (*Agropyron intermedium*), Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*), alfalfa (*Medicago sativa*) and clover (*Trifolium spp.*).

Figure 1. Map of improved summer pastures grazed by supplemented and unsupplemented cows and calves.

Cows and calves were weighed at the beginning and end of the study period and cows were also scored for body condition (1-9 scale) at these times. All supplemented cows and calves and 10 unsupplemented cows and calves were dosed with sustained release Cr_2O_3 boluses on day 21 of the trial to administer chromium oxide as an external

marker. Cows received adult cattle boluses and each calf received 2 sheep chromium boluses. Fecal grab samples were collected after a 7 d equilibrium period on days 28, 30 and 32, and composited to estimate fecal output (FO). Ytterbium (Yb) chloride was added to the liquid supplement on day 15, and fecal grab samples were taken on days 21 and 28, analyzed separately, and then averaged to estimate individual supplement intake. Fecal samples were dried in a forced-air oven (50° C), ground through a 1-mm screen, and analyzed for DM (AOAC, 1990), NDF (Van Soest et al., 1991), Cr by atomic absorption spectrophotometry (Ellis et al., 1982), and Yb by inductively coupled plasma emission spectroscopy (Fassel, 1978). Extrusa samples were collected on d 22 using two ruminally cannulated crossbred cows per treatment, and incubated in situ for 48 h using a technique described by Bowman et al., (1995a) to determine DM, OM and NDF digestibility; and carboxymethylcellulase activity (Silva et al., 1987). Estimates of individual FO, forage intake and liquid supplement intake were obtained using the following equations:

$$\text{FO} = \text{Cr marker intake} / \text{fecal Cr conc.}$$

$$\text{Forage intake} = \text{FO} / (1 - \text{digestibility})$$

$$\text{Supplement intake} = \frac{(\text{fecal Yb conc.}) * \text{FO}}{\text{supplement Yb conc.}}$$

Calf fecal output estimates were adjusted for milk components as described by Ansotegui (1986) in order to calculate forage intake. Estimates of calf fecal output were also adjusted for milk components as described by Sowell et al. (1996) to calculate supplement intake. Milk intake was estimated for all supplemented calves and 10 control

calves on d 32 using a weigh-suckle-weigh technique with a 6 h separation interval (Williams et al., 1979). The metabolizable energy (ME) of the forage was calculated as described by Ansotegui et al. (1991) where $ME = 3.6 \times DOM$. Metabolizable energy was then converted to NE_m and NE_g (NRC, 1984).

Statistical Analysis

Data were analyzed using the GLM procedure of SAS (1988) with individual animal as the experimental unit. Means were separated with LSD tests when significant treatment effects were detected ($P < .10$). Least square means and P-values are reported. There was a difference ($P < .10$) in initial weight of cows and calves between the treatment groups. Cow initial weight was significant ($P < .10$) as a covariate for ending weight, end BCS and DMI as a % BW, and calf initial weight was significant ($P < .10$) as a covariate for WW and 205-d adjusted WW. Means for these variables are reported using the covariate model, while results for all other variables are reported using the statistical model containing only treatment. Data from the Supp group were also analyzed using the REG and CORR procedures of SAS (SAS, 1988) in order to determine if there was a correlation or linear relationship between cow and calf performance with supplement, forage, and milk intake. Correlation coefficients (r values), coefficients of determination (r^2 values) and P-values for these relationships are reported.

Results and Discussion

Forage Quality and Production

Forage production and chemical composition of hand-clipped samples were similar between pastures grazed by supplemented and unsupplemented cattle (Table 1).

Table 1. Production and quality of improved summer pastures grazed by cows and calves during three time periods based on hand-clipped samples.

Time period	Production (kg/ha) ¹	% N	% ADIN	% NDF	% ADF	% ADL
Unsupp						
7/28 – 8/8	557	1.1	.10	67.1	39.2	5.4
8/9 – 8/29	2692	1.4	.09	63.0	32.8	3.5
8/30 – 10/3	2314	1.3	.08	59.7	31.8	3.0
Supp						
7/28 – 8/12	2885	1.6	.11	62.1	33.4	4.3
8/13 – 9/11	1987	1.1	.08	62.6	34.4	4.5
9/12 – 10/3	2538	1.8	.11	58.6	31.9	4.3

¹ During the intake sampling period, forage production averaged 2692 kg/ha and 2440 kg/ha for pastures grazed by unsupplemented and supplemented cattle, respectively.

Extrusa was only collected from pastures grazed by cattle during the intake sampling period. The forage selected would be considered of medium quality averaging 8.8 % CP, 72.9 % NDF and 43.5 % ADF (Table 2). There was no difference ($P > .10$) in 48 h DM digestibility, NDF digestibility, or OM digestibility between treatments (Table 2); however, there was a large amount of variation between the cannulated cows in the unsupplemented treatment group. Other researchers have reported that liquid supplementation increased digestibility of fall and winter native forages (Bowman et al., 1995a; Daniels et al., 1998), but I was unable to detect a difference in forage digestibility

of improved summer pastures due to liquid supplementation. Silva et al. (1987) reported that carboxymethylcellulase (CMCase) activity was highly correlated with DM digestibility. There was no difference ($P > .10$) in CMCase activity between treatment groups (Table 2).

Table 2. Forage quality and in situ disappearance of extrusa collected during the intake sampling period from improved pastures grazed by cattle with or without liquid supplementation¹

Item	Unsupplemented	Supplemented
Composition, %		
N	1.52	1.28
ADIN	.42	.18
NDF	73.0	72.8
ADF	43.7	43.3
ADL	9.1	5.7
Ash	11.5	14.5
DM disappearance, %		
48 h	55.5 ^a	69.8 ^a
OM disappearance, %		
48 h	54.2 ^a	70.6 ^a
NDF disappearance, %		
48 h	48.4 ^a	68.6 ^a
CMCase ² , $\mu\text{moles/g min}^{-1}$		
48 h	2.7 ^a	4.2 ^a

¹ Values in table expressed on a DM basis

² Carboxymethylcellulase activity

^a Means in a row with a common superscript letter are not different ($P > .10$)

Supplement Intake

Estimated liquid supplement intake by cows averaged .5 kg/d on an as-fed basis (Table 3). Fifty percent of the cows consumed less than .45 kg/d, 42 % consumed between .45 and 1.4 kg/d, and 8 % consumed more than 1.4 kg/d liquid supplement on an as-fed basis. While supplement intake could only be estimated for 26 cows, Yb was

found in all but two of the 47 fecal samples. Therefore, only two cows appeared to consume no supplement.

Estimated liquid intake supplement by calves averaged .2 kg/d on an as-fed basis (Table 3). Ninety-one percent of the calves consumed less than .45 kg/d, 9 % consumed between .45 and 1.4 kg/d, and no calves consumed more than 1.4 kg/d of liquid supplement. While supplement intake could only be estimated for 11 calves due to the problem with predicting fecal output, Yb was detected in the feces of the 44 calves for which fecal samples were available, indicating that calves were consuming the liquid supplement.

Cows consumed more ($P = .09$) kg of supplement per day than calves (Table 3); however, when supplement intake was expressed as a % BW, there was no difference ($P > .10$) in supplement intake by cows and calves, averaging .04 % BW.

Table 3. Liquid supplement intake and distribution by cows and calves grazing improved pastures

Item	Cows	Calves
No. of animals	26	11
Supplement intake		
DM, kg/d	.3 ^b	.1 ^a
As-fed, kg/d	.5	.2
% BW	.04 ^a	.04 ^a
Min, kg/d as-fed	0	.1
Max, kg/d as-fed	2.2	.5
CV, %	96	81
Intake distribution, %		
< .45 kg/d as-fed	50	91
.45 – 1.4 kg/d as-fed	42	9
>1.4 kg/d as-fed	8	0

^{a,b} Means in a row without a common superscript letter differ ($P < .10$)

The target consumption rate recommended by the manufacturer was 1.0 kg/pair/d (as-fed). Rate of liquid supplement disappearance from the tank on an as-fed basis was 1.0 kg/pair/d for the entire study period and .8 kg/pair/d during the intake collection period. Estimates of individual liquid supplement intake obtained using the Yb marker method averaged .5 kg/d (as-fed) for cows and .2 kg/d (as-fed) for calves, for a total of .7 kg/pair/d (as-fed). Combined estimates of cow and calf liquid supplement intake obtained using the Yb marker method agreed with measurements of liquid supplement disappearance from the tank.

Cow and Calf Performance

Average daily gain (ADG) of supplemented cows was two times greater ($P = .03$) than ADG of unsupplemented cows, and supplemented cows were 9 kg heavier ($P = .03$) at weaning than unsupplemented cows (Table 4). There was no difference in BCS change ($P > .10$) between the two treatments.

Table 4. Weights, ADG, and body condition score of cows grazing improved pastures with or without liquid supplementation

Item	Unsupp	Supp	SE	P-value
No. of animals	54	47		
Weight, kg				
Initial	591	637	7.7	.0001
Ending ¹	620	629	2.4	.01
Wt change	8	16	2.4	.03
ADG, kg	.12	.24	.035	.03
BCS				
Initial	5.3	5.2	.08	.96
Ending ¹	5.0	4.7	.08	.004
Change	-.3	-.4	.07	.43

¹ Initial weight used as a covariate in data analysis

Average daily gain by supplemented calves was 30 % higher ($P < .01$) than ADG of unsupplemented calves, and supplemented calves were 17 kg heavier ($P < .01$) at weaning than unsupplemented calves (Table 5). Adjusted weaning weights (205-d) were 12 kg higher ($P < .01$) for supplemented than unsupplemented calves. Due to differences in cow age between treatments, attention should be focused on ADG and adjusted WW.

Table 5. Weights and ADG of calves grazing improved pastures with or without liquid supplementation

Item	Unsupplemented	Supplemented	SE	P-value
No. of calves	54	47		
Weight, kg				
Initial	202	224	2.9	.0001
Ending (WW) ¹	282	299	1.7	.0001
205-d adj. WW ¹	267	279	2.0	.0001
Wt change	67	88	1.6	.0001
ADG, kg	1.0	1.3	.02	.0001

¹ Initial weight used as a covariate in data analysis

Age and weight of dam can influence calf WW through the amount of milk they produce (Neville, 1962; Melton et al., 1967; Rutledge et al., 1971). Younger cows produce less milk than more mature animals, but there is no adjustment factor for milk production when computing 205-d adjusted WW for calves of 5 - 9 yr old cows. Havstad et al. (1989) reported that there were no differences in calf ADG between cows 4- to 9-yr old in 6 of 7 pre-weaning periods. There is conflicting evidence in the literature as to the affect of cow weight on milk production. Rutledge et al. (1971) reported that heavier cows tended to produce more milk; however, Wilson et al. (1969) found the opposite to be true and also reported that calves of large and small cows had similar gains. Neville

(1962) and Melton et al. (1967) found no difference in milk production between cows of different weights. Bellows and Thomas (1976) reported that calf weight gains were not significantly affected by age of cow or feed treatment of dam. Peischel (1980) also reported that age of dam had no effect on calf ADG.

Forage Intake

Forage intake was 64 % greater ($P < .01$) by supplemented cows and calves than unsupplemented cattle on a % BW basis (Table 6). Bowman et al. (1995a) reported a 47 % increase in forage intake of liquid supplemented cows grazing native fall range and Daniels et al. (1998) also reported that liquid supplementation increased forage intake by 47 % for cows grazing native winter range. These researchers attributed increased forage intake to increased digestibility due to liquid supplementation.

Table 6. Forage intake by cows and calves grazing improved pastures with or without liquid supplementation

Item	Unsupp	Supp	SE	P-value
No. of cows	9	26		
Forage intake				
DM, kg/d	14.1	22.3	1.59	.001
% BW ¹	2.2	3.6	.26	.001
No. of calves	10	13		
Forage intake				
DM, kg/d	3.5	7.1	.59	.0003
% BW	1.7	2.8	.24	.004

¹ Initial weight used as a covariate in data analysis

Forage intake by calves on this study is in agreement with what has been previously reported in the literature for calves grazing native range. Ansotegui (1986)

reported that forage OMI of suckling calves on native range, averaged 1.2 to 2.3 % BW, similar to that of mature cows. Peischel (1980) reported that forage intake by calves grazing native range was 2.4 % BW. Boggs et al. (1980) estimated that calf forage DMI ranged from .62 % BW in May to 2.2 % BW in September.

Fifty-one supplemented cow/calf pairs were dosed with sustained release Cr_2O_3 boluses to estimate fecal output, however, chromium (Cr) was only detected in 27 % of the calves' feces. Swensson et al. (1995) reported that one sheep bolus could be used to estimate fecal output in calves less than 150 kg. The calves on this study averaged 214 kg and were dosed with two sheep boluses for a combined release rate of .27 g Cr/d. Four percent of the sheep boluses were found regurgitated in the field. Researchers at Utah State University successfully used one and two sheep boluses to estimate fecal output of 300 kg cannulated calves in confinement (K. Olsen, personal communication). It seems probable that in the field, the boluses were regurgitated due to the large size of the calves.

Milk Intake

There was no difference ($P = .24$) in 24-h milk intake estimates between the supplemented and unsupplemented treatments, averaging 12 kg/d (Table 7). While not statistically different at the .10 alpha level, the difference in milk intake between the treatments could be biologically important. There might not have been enough observations to detect a difference at the .10 alpha level. Ansotegui et al. (1991) reported that Angus x Hereford calves grazing native range consumed 5.2 to 6.0 kg milk per day in August and September of one year, and averaged 9.7 kg/d in August and September of the

next year. It seems probable that purebred Angus cows grazing improved pastures would produce more milk than cows grazing native range.

Table 7. Milk intake by calves grazing improved pastures with or without liquid supplementation

Item	Unsupplemented	Supplemented	SE	P-value
No. of animals	10	36		
Milk intake, kg/24 h	9	15	3.5	.27

Mechanism of Improved Performance

Jones (1966), Butterworth et al. (1973), and Landlands and Donald (1978) reported that grazing animals responded more to supplementation on lower quality forages. Bowman et al. (1995b) concluded that performance and forage intake by supplemented animals were confounded by pasture condition and forage quality. Moore et al. (1995) compiled data from 51 studies and concluded that animal response to supplementation depends on the ratio of digestible organic matter (DOM) to CP content of the forage. When $\text{DOM:CP} > 7$, supplementation will increase animal weight gains and forage intake. However, when the $\text{DOM:CP} < 7$, weight gains could be increased, but forage intake was generally decreased. The DOM:CP in the current study was 8.8 and increases in gain and forage intake by supplemented animals were observed as predicted by Moore et al. (1995).

Calf WW can be affected by breed, sire, sex of calf, birth weight and age at weaning (Neville, 1962; Melton et al., 1967; Rutledge et al, 1971). Calves of both treatments in the current study were of the same breed and sex. There were 25 different sires for 101 calves, so results were probably not confounded by sire, and the only

variable with differences by sire was initial calf weight ($P < .10$). Calf birth weight and age at weaning were not different ($P > .10$) between treatments, averaging 39 kg and 227 days, respectively.

Other researchers have documented improvements in calf performance due to liquid supplementation. Grelen and Pearson (1977) reported that year-round liquid supplementation increased calf WW by 7 kg, even though these calves were 14 d younger at weaning, than calves of cows that were supplemented with cottonseed cake only in the winter. Hennessy (1986) reported calves of liquid supplemented heifers had 20 % higher WW than calves of unsupplemented heifers and attributed this improvement to increased milk production of the dam. He estimated milk intake at 50 d post calving during the time of peak lactation. Milk intake by the calf is the most important factor influencing weaning weight (Neville, 1962; Rutledge et al., 1971); however, the influence of milk intake on calf performance declines as lactation progresses (Furr and Nelson, 1964; Ansotegui et al., 1991). Milk intake was estimated late in lactation (180 d) in the current study and there was no difference between treatments. In addition, calf ADG was not correlated ($r = .36$; $P = .37$) with calf milk intake (Table 8).

There was also no correlation ($P > .10$) between calf ADG and calf forage intake, calf supplement intake, or the concentration of Yb in calf feces (Table 8). Calf ADG was not linearly related ($P = .53$) to calf milk intake, forage intake and supplement intake (Table 9). Adding cow supplement intake as a dependent variable to the equation did not improve the relationship ($P = .86$). Calf milk intake was not correlated ($P > .10$) with cow forage intake, cow supplement intake or Yb concentration in cow feces. Calf milk

intake was not linearly related ($P = .89$) to cow forage and supplement intake. Calf ADG was not correlated ($P > .10$) with cow supplement intake or Yb concentration in cow feces. Cow ADG and change in BCS were not correlated ($P > .10$) with cow forage intake, cow supplement intake, or Yb concentration in cow feces. Cow ADG and BCS change was not linearly related ($P > .90$) to cow forage and supplement intake.

Nolan et al. (1974) reported that the rate of liveweight change in supplemented heifers was significantly correlated with liquid supplement intake. Lobato et al. (1980) reported a positive correlation between liveweight gains of sheep and individual supplement intake of oats and hay, but not molasses. In contrast, Mulholland and Coombe (1979) did not find a strong relationship between intake of a urea, molasses and mineral supplement and rate of liveweight change in wethers.

Table 8. Correlation of calf and cow performance with forage, milk and supplement intake; and Yb concentration in feces.

Item	CALF				COW		
	Milk Intake	Forage Intake	Supp Intake	Fecal Yb conc.	Forage Intake	Supp Intake	Fecal Yb conc.
Calf ADG, n	36	13	11	44	26	26	47
r	.16	.20	.09	-.04	-.19	-.08	-.16
P-value	.37	.52	.78	.77	.36	.72	.30
Cow ADG, n	-	-	-	-	26	26	47
r	-	-	-	-	.03	.00	-.02
P-value	-	-	-	-	.90	.99	.92
BCS change, n	-	-	-	-	26	26	47
r	-	-	-	-	.00	-.05	-.19
P-value	-	-	-	-	1.0	.82	.20
Calf MI, kg/6h, n	-	10	-	-	22	22	36
r	-	.34	-	-	-.08	-.08	-.08
P-value	-	.34	-	-	.73	.72	.66

Table 9. Linear regression equations, coefficients of determination, P-values, and numbers of animals for relationships between cow and calf performance and milk, forage, and supplement intake.

Equation	R ²	P-value	n
CalfADG = 2.7 + .01CalfMilkIntake + .01CalfForageIntake - .15CalfSuppIntake	.40	.53	8
CalfADG = 2.4 + .01CalfMilkIntake + .01CalfForageIntake + .27CalfSuppIntake + .13CowSuppIntake	.55	.86	6
CalfMilkIntake = 10.6 - .04CowForageIntake - .92CowSuppIntake	.01	.89	22
CowADG = .48 + .001CowForageIntake - .002CowSuppIntake	.0007	.99	26
CowADG = .48 + .001CowDMI	.0007	.90	26
CowBCSChange = -.36 - .0001CowForageIntake - .03CowSuppIntake ¹	.0022	.98	26
CowBCSChange = -.38 - .0001CowDMI	.0000	.99	26

¹ BCS = Body condition score

Protein and energy requirements of calves (NRC, 1984) are presented in Table 10. Using the NRC requirements as guidelines, unsupplemented calves consumed adequate amounts of energy to gain 1.7 kg/d, but only consumed the amount of protein required to gain .7 kg/d. Unsupplemented calves gained 1.0 kg/d. Wallace (1988) suggested that protein is the first limiting nutrient of cattle grazing rangelands and protein in the current study was also the first limiting nutrient for unsupplemented calves grazing improved summer pastures. Supplemented calves gained 1.3 kg/d and were receiving adequate amounts of energy and protein from the forage and milk in order to meet the requirements for this level of gain. Based on the amounts of protein and energy consumed by

supplemented calves, the predicted daily gain based on NRC requirements was > 1.8 kg/d (NRC, 1984).

Table 10. Energy and protein requirements and amounts consumed by calves grazing improved summer pastures with or without liquid supplementation.

	NE _m , Mcal/d	NE _g , Mcal/d	CP, g/d
Unsupp			
Requirements ¹	4.84	2.75	765
Consumed ²	7.66	4.62	630
Supp			
Requirements ¹	4.84	3.67	860
Consumed ²	17.95	11.85	1063
With Supp	18.38	12.14	1107

¹ NRC (1984), large frame bull calves, avg wt 250 kg, ADG 1.0 kg/d (Unsupp) and 1.3 kg/d (Supp)

² Amount consumed from milk and forage

Liquid supplementation costs for the study period totaled \$1110. The supplemented calves weaned a total of 925 kg more than the unsupplemented calves. If the total cost of supplementation could only be recovered through the sale of weaned calves, then the cost for each additional .45 kg (1 lb) of gain was \$.54. October, 1997 prices for bull calves in Montana averaged \$.74/.45 kg. This represents a conservative cost analysis since no benefits of supplementing cows were included, but under these conditions liquid supplementation was cost effective.

Conclusion

Calves consumed the same amount of supplement on a percent body weight basis as mature cows. Liquid supplementation increased ADG and forage intake by cows and suckling calves. Improved calf performance was not linearly related to milk intake, forage intake or supplement intake. Liquid supplemented calves were able to meet their protein requirements based on their consumption of supplement, forage and milk; whereas, unsupplemented calves were protein deficient. Late summer supplementation can improve performance of suckling calves and was economical given October cattle prices in Montana.

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SUPPLEMENT FEEDING BEHAVIOR BY A MIXED-AGE GROUP OF COWS AND CALVES

Summary

Forty-seven mixed-age (6 – 9 yr) Angus cows (633 kg) and their bull calves (262 kg) were used to determine cow and calf use of liquid supplement offered in an open tank. The study was conducted in southwestern Montana from July 28, 1997 to October 3, 1997. Cattle grazed improved summer pastures during the study. All cows and calves were fitted with a radio frequency (RF) eartag in order to electronically record each visit by an animal to the supplement feeder. Ytterbium chloride was added to the liquid supplement (41 % CP, DM basis) to estimate individual supplement intake. Cows were present at the tank a higher ($P = .001$) proportion of days than calves, averaging 72 % and 65 %, respectively. There was no difference ($P > .10$) in time spent at the tank between cows and calves, averaging 4.9 min/d. Statistically, cows had more ($P = .03$) bouts/d than calves (1.3 vs 1.2 bouts/d); however, this difference is probably not biologically important. A higher ($P < .10$) proportion of 6- and 9-yr-old cows were present at the tank per day than 8-yr-old cows; but there was no difference ($P > .10$) between the proportion of 6- and 7-yr-old cows, or 7- and 8-yr-old cows present at the tank on a daily basis. Time spent at the feeder (min/d) was lowest for 7-yr-old cows, intermediate for 6- and 8-yr-old cows, and highest for 9-yr-old cows ($P < .10$). There was no difference ($P > .10$) in bouts/d between age groups. Bout duration was greatest ($P < .10$) by 9-yr-old cows. There was no difference in min/bout between 6- and 7-yr-old cows, or between 7- and 8-

yr-old cows ($P > .10$), but min/bout was greater ($P < .10$) for 8-yr-old cows than 6-yr-old cows. Time at the tank was linearly related ($P < .10$) to supplement intake, but had limited predictive capabilities ($R^2 = .35$ to $.54$). Time at the tank ranked use by cows and calves the same ($P < .10$) as supplement intake. Time at the tank can be used to classify calves, but not cows, as low and medium consumers of supplement.

Introduction

Wagnon (1965) concluded that varying weight gains of supplemented cattle are due to variation in individual supplement consumption caused by social dominance of animals within the herd. Social dominance of sheep and cattle in hand-fed situations has been shown to be associated with age (Wagnon, 1965; Friend and Polan, 1974; Ducker et al., 1981), weight (Wagnon et al., 1966; Lobato and Beilharz, 1979) and breed (Wagnon et al., 1966; Arnold and Maller, 1974). Bowman and Sowell (1997) suggested that behavior of supplemented grazing animals has not been adequately addressed in the literature. Few researchers have reported supplement intake or use by different age cows or their calves.

Assessing animal behavior usually involves visual observations, which are labor and time intensive. Marker methods used to estimate supplement intake are less labor intensive, and while providing an estimate of supplement intake, are generally only obtained a few times during a study period and may not be indicative of actual or long term behavior patterns regarding supplement use. Basarab et al. (1996) and Sowell et al. (1998) used radio frequency technology to document feeding and watering behavior of

feedlot cattle. Tait and Fisher (1996) used electronic equipment to estimate use of a molasses feedblock by individual grazing steers and reported that all steers consumed the block and estimated individual intake ranged from .72 to 1.65 kg/d. Cockwill et al. (1998) used radio frequency technology to identify the proportion of cows and calves attending a mineral feeder. Putnam et al. (1968) reported that time at the feedbunk was related to the amount of feed consumed. Currently, there is a radio frequency technology available that can identify multiple animals at the feeder at one time. The objectives of this study were to (1) document calf use of a liquid supplement in order to compare cow and calf use of an open supplement tank, (2) document behavior by a mixed-age group of cows at an open supplement tank, and (3) compare the relationship between supplement intake and time spent at the supplement tank.

Materials & Methods

The study was conducted on a ranch in southwestern Montana from July 28, 1997 to October 3, 1997. Forty-seven Angus cows (age 6-9 yr, 633 kg) and their bull calves (262 kg) had access to a commercially available liquid supplement in an open tank (Nutra-Lix, Inc., Billings, MT). The supplement was 22 % CP on an as-fed basis (43.5 % of the CP from urea, as-fed) and 41 % CP on a DM basis. The supplement tank was 1.2 m in diameter and 45 cm high (Figure 2). An antennae (Growsafe[®], Inc., Calgary, Canada) was placed above the tank, and all cows and calves were fitted with a radio frequency (RF) eartag at the beginning of the study in order to electronically record each visit to the supplement feeder. Ytterbium chloride was added to the supplement tank and

fecal Yb concentration was used to estimate and rank supplement intake by individual animals (Curtis et al., 1994).

Figure 2. Liquid supplement feeder with Growsafe[®] antennae.

Cattle grazed improved irrigated pastures throughout the summer and were rotated three times between two different pastures (Figure 3). Cattle grazed a 111 ha pasture dominated by Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*) and clover (*Trifolium spp.*) from July 28 to August 12, and September 12 to October 3. Willows (*Salix spp.*) lined the creek that ran the length of the west side of the pasture and at the south end there was a group of cottonwood trees. The liquid supplement feeder was placed at the north end of the pasture, which was bordered by a county road. Cattle grazed a 92 ha pasture on a hillside dominated by intermediate wheatgrass (*Agropyron intermedium*) and alfalfa (*Medicago sativa*) from August 13 to September 11. There was

no cover available in this pasture and a ridge ran east to west through the center. An irrigation ditch ran the length of the west side of the pasture and the supplement feeder was located at the north end of the pasture which was also bordered by the same county road (Figure 3). It was during this time that Yb was added to the tank and fecal samples were collected to estimate supplement intake.

Figure 3. Map and description of improved summer pastures grazed by supplemented cows and calves.

System Description

The Growsafe[®] system was used to determine time spent at the tank (min/d), visits per day (bouts/d), and bout duration (min/bout). The Growsafe[®] system consists of

four component parts: RF eartag (passive transponder), antennae, reader panel and computer. Prior to insertion into the animals' left ear, all RF eartags were scanned into the system to create a file and to make sure they were working. The antennae and reader panel were positioned 53 cm above the supplement tank. The antennae was positioned above the tank at a distance that allowed adequate room for animals to get to the supplement and so that the RF eartag would be within reading distance when the animals were consuming supplement. Each time the RF eartag was directly underneath, and within 45 cm of the antennae, the reader panel (which queries every 1.25 s) identified the animal and exact time it was present. This information was sent to a computer located nearby in a waterproof box. A synchchip in the reader panel also had a RF identification number and was queried constantly. This provided knowledge of when the equipment was working properly and what time the system went down. The electronic equipment was plugged into a surge protector and a universal power source, which maintained an electrical current to keep the equipment running for about 15 minutes in case the voltage in electrical lines fluctuated too low to maintain power. Location of the supplement tank in the pastures was determined by accessibility to an electrical power source.

An observer collected 40 hours of visual observations on 11 separate days. Visual observations were collected to determine the proportion of time cattle spent consuming supplement while under the antennae, and to identify the amount of time between bouts. Different bouts were defined as being separated by more than 30 minutes of inactivity at the tank. The Growsafe[®] system was validated using visual observations and the reading distance was checked once a week to make sure the equipment was working properly.

Electronically recorded visits to the supplement tank by each individual animal were used to calculate min/d, bouts/d, min/bout, min per day present (min/d based only on days animals were present at the tank) and bouts per day present (bouts/d based only on days animals were present at the tank). Days that cattle were worked, moved to another pasture, or that the computer was down for more than 30 minutes were excluded from the data analysis. Therefore, 45 days of data for each animal were used in the data analysis.

Statistical analysis

Individual animals were considered experimental units and data were analyzed using the GLM procedure of SAS (1988) with individual animal within type or age as the testing term, because repeated measures were made on each animal (Gill and Hafs, 1971). Means were separated using LSD tests ($P < .10$). Percent animals present per day was analyzed using chi-square analysis (SAS, 1988).

The REG procedure of SAS (SAS, 1988) was used to determine if there was a linear relationship between time spent at the tank and fecal Yb concentration.

Cows and calves were ranked from high to low based on time at the tank (min/d) and supplement intake. Spearman's rank correlation coefficient was calculated to determine if there was an association between the rank scores for time at the tank (min/d) and supplement intake (SAS, 1988). The distribution of the rankings of the two methods were also compared for independence using a non-parametric, two-tailed Wilcoxon's signed rank test (Steel and Torrie, 1980).

Supplement intake was used to categorize cows and calves as low ($< .45$ kg/d, as-fed), medium (.45 – 1.4 kg/d, as-fed) or high (> 1.4 kg/d, as-fed) consumers of supplement. Average daily time at the tank was used to categorize cows and calves as low (0 – 5 min/d), medium (5 – 10 min/d) and high (> 10 min/d) users of supplement. To determine the degree of independence between categorizations by supplement intake and time, chi-square analysis was conducted using a 2-way contingency table (SAS, 1988). Association groups were determined according to the probability of such associations occurring by chance. The high categories of both methods were excluded from the analysis because they represented less than 5 observations in the cells of the contingency table which render the statistical inference invalid for those columns (McClave and Dietrich, 1985). One cell of the contingency table in the analysis for calves still contained less than 5 observations and Fisher's exact test was used to obtain the probability level for this analysis (McClave and Dietrich, 1985).

Results and Discussion

Equipment Validation

The difference between visual observations and electronically recorded in, out and total times were analyzed using a paired T-test (SAS, 1988). The average duration of feeding visits ($n = 62$) recorded by an observer was 12 seconds different ($P < .0001$) than the average duration of feeding visits recorded electronically by the computer. Differences could be due to inability of the observer to accurately determine when the RF tag was directly under the antennae or asynchrony between the observer's watch and

computer's clock. This is similar to the 13 s difference between duration of observed and electronically recorded visits to the feedbunk using similar equipment in the feedlot (Sowell et al., 1998). Thirteen percent (11 of 88) of visual observations were not recorded by the computer. All but two of these observed visits were less than 10 s in length. The electronic equipment queries every 1.25 s and it is possible that these animals missed the query cycle, or that the RF tag was not directly underneath and within reading distance of the antennae.

Cows spent more ($P < .0001$) time while under the antennae actually consuming supplement than calves did, averaging 46 % for cows and 18 % for calves. The observer noted that due to the height of cows in relation to the antennae, cows had to duck their heads to get under the antennae and would bring their heads back up and out while pausing between licks. Calves however, due to their height, still had their heads under the antennae when they paused between licks (Figure 2).

Cow and Calf Use

All cows and calves were electronically recorded as having visited the supplement tank. More than 90 % of cows and calves made their first visit to the supplement feeder within the first six days on pasture (Table 11).

Table 11. Percentage of animals and day of first visit to the liquid supplement tank.

	Day of first visit to supplement feeder ¹						
	1	2	3	4	5	6	>6
% Cows	49	17	19	6	2	0	6
% Calves	40	19	32	2	2	0	4

¹ Day 1 is first full day cattle were on a pasture.

Cows visited the tank a higher ($P = .001$) proportion of days than calves did (Table 12), averaging 72 % and 65 % for cows and calves, respectively. The total number of days a cow was present at the tank was linearly related ($P < .01$; $R^2 = .20$) to the total number of days her calf was present at the tank. The total time a cow spent at the tank was also linearly related ($P < .01$; $R^2 = .20$) to the total time her calf spent at the tank. Cows and calves usually visited the supplement tank as part of a group; however, the observer noted that cow/calf pairs did not always visit the tank together. Cockwill et al. (1998) also electronically recorded attendance at a mineral feeder by individual grazing cows and calves, but reported that fewer calves than cows attended the mineral feeder.

Table 12. Individual animal use of a liquid supplement tank by cows and calves grazing improved summer pastures.

	Cow	Calf	SE	P-value
n^1	2111	2111		
Min/d	5.2	4.7	.13	.40
Bouts/d	1.3	1.2	.02	.05
n^1	1364	1519		
Min/bout	3.9	4.0	.08	.62
Min/d visited	7.0	7.1	.17	.86
Bouts/d visited	1.8	1.8	.03	.65
n^1	2111	2111		
% Present/d ²	72	65		.001

¹ n = cow-days or calf-days

² Data analyzed using chi-square analysis

There was no difference ($P > .10$) in time spent at the supplement tank between cows and calves (Table 12). Statistically, cows had more ($P = .03$) bouts per day than calves; however, these numbers may not be biologically important (Table 12). Bout

duration was not different ($P > .10$) between cows and calves, averaging 4 min/bout.

When minutes and bouts were averaged only across days animals were present at the tank, there was also no difference ($P > .10$) between cows and calves, averaging 7.1 min/d visited and 1.8 bouts/d visited.

Fifty-five percent of calves spent 0 to 5 min/d at the supplement feeder, 43 % spent 5 to 10 min/d, and only 2 % of calves spent more than 10 min/d at the supplement feeder (Figure 4). Fifty-five percent of cows spent 0 to 5 min/d at the supplement feeder, 34 % averaged 5 to 10 min/d, and 11 % spent more than 10 min/d at the supplement feeder (Figure 4). No cows or calves spent more than 15 min/d at the supplement feeder.

Figure 4. Frequency distribution of average daily time spent at the feeder by cows and calves grazing improved summer pastures.

Sowell et al. (1995) collected observations of cow behavior at two lick-wheel feeders and also used a 30-minute separation interval between different bouts. Based on 8 days of observations, they reported that cows visited the tanks 69 % of the days and

averaged 12.5 min/d at the supplement feeders. The number of bouts/d averaged 1.1 to 1.5 for the two tanks. Twenty-five percent of cows spent less than 5 min/d at the supplement feeders. Ernst (1973) reported that yearling heifers visited a roller lick tank containing a urea-molasses mixture at least once a day and bout duration averaged 4 min/bout. This author used a 5 minute separation interval between bouts and reported that cows spent 26 min/d at the feeder and averaged 6.5 bouts/d. Ernst (1973) also noted that cattle came to the feeder in groups.

In the current study, an observer recorded that cattle came to the tank in groups but left individually. When animals decided to visit the feeder, they headed straight for the tank, and when they were ready to leave they left rapidly and walked straight away. Animals were observed scratching on the antennae, playing, resting and nursing while at the tank. The scene at the tank was usually pretty calm, but cows and calves were observed butting or usually just pushing other cows and calves out of the way. Generally the animal being pushed away did not leave the tank area but just moved to another side of the tank. Generally, five to six animals (cows and/or calves) were observed with their heads under the antenna and consuming at the same time.

Age of Cow

Nine and 6-year-old cows were present at the tank a higher ($P < .10$) percentage of days than 8-yr-old cows (Table 13). Nine-yr-old cows were present at the tank a higher ($P < .10$) percentage of days than 7-yr-old cows. There was no difference ($P > .10$) in the proportion of days present at the tank between 7- and 6-yr-old cows or between 7- and 8-

yr-old cows. Wagnon (1965) reported that cows missing an occasional day were 7, 8 and 10-year-old cows or those of mid to higher social rank. Data from the current study is in agreement with those findings.

Table 13. Individual animal use of an open liquid supplement tank by four age groups of cows grazing improved summer pastures.

	Cow				SE	P-value
	6 yr	7 yr	8 yr	9 yr		
No. of cows	14	3	20	10		
n ¹	630	135	896	450		
Min/d	4.4 ^b	3.2 ^a	4.9 ^b	7.6 ^c	.31	.03
Bouts/d	1.4	1.0	1.2	1.5	.03	.26
n ¹	475	94	599	351		
Duration, min/bout	3.1 ^a	3.5 ^{ab}	3.8 ^b	5.1 ^c	.18	.02
Min/d visited	5.7 ^a	4.9 ^a	6.9 ^b	9.5 ^c	.36	.03
Bouts/d visited	1.8	1.5	1.8	1.9	.06	.35
n ¹	630	135	896	450		
Days present, % ²	75 ^{bc}	70 ^{ab}	67 ^a	78 ^c		

¹ n = cow*days

² Data analyzed using chi-square analysis

^{abc} Means in a row without a common superscript letter differ (P < .10).

Time at the tank (min/d) was highest (P < .10) by 9-yr-old cows, intermediate by 6- and 8-yr-old cows and lowest by 7-yr-old cows (Table 13). There was no difference (P > .10) in bouts/d between age groups, averaging 1.3 bouts/d. Bout duration (min/bout) was highest for 9-yr-old cows (P < .10). Six-yr-old cows spent fewer (P < .10) min/bout than 8-yr-old cows, but there was no difference (P > .10) in bout duration between 6- and 7-yr-old cows or between 7- and 8-yr-old cows. On days that cows did visit the tank, cows averaged 1.8 bouts/d visited and there was no difference (P > .10) between age

groups. On days that they did visit the tank, 9-yr-old cows averaged more ($P < .10$) min/d visited than all other ages; 6- and 7-yr-olds spent the least amount of time at the tank, and 8-yr-olds were intermediate.

Wagnon (1965) reported that social dominance was associated with age and that the youngest age group of a herd (2- or 3-yr-old cows) was usually driven away from the supplement by older animals. Cattle on that study were called to the supplement feeding area and hand-fed. Data by Sowell et al. (1995) reported that 2-year-old cows visited the self-fed supplement feeder less frequently and spent less time there than 3-yr-old cows. Friend and Polan (1974) reported that there was a quadratic relationship between average time spent eating and social rank of dairy cattle, so that mid-ranked cows spent the least amount of time eating. In the current study, there were only three 7-yr-old cows in the herd and it seems possible that the results could have been influenced by sample size of the different age groups.

Supplement Intake vs Time at the Feeder

This study provides an opportunity to compare the relationship between supplement intake and time at the tank. Fecal samples were collected on two separate days (1 week apart) and analyzed separately for Yb. The regression between calf fecal Yb concentration, and time spent at the tank one day prior to fecal sampling, provided the best linear relationship ($P = .0001$; $R^2 > .35$) between Yb concentration and time spent at the tank by calves (Figure 5a and 5b). The best linear relationship between cow fecal Yb concentration and time spent at the tank was obtained by including the time spent a total

of 2 or 3 d prior to fecal sampling ($R^2 = .43$ and $.54$, $P = .0001$). There was some variation in the linear relationship between days for both cows and calves as illustrated in Figure 5.

a. Linear relationship between time at the tank one d prior to Yb sampling on 8/18/97 and Yb concentration in calf feces.

b. Linear relationship between time at the tank one d prior to Yb sampling 8/25/97 and Yb concentration in calf feces.

c. Linear relationship between total time at the tank 3 d prior to Yb sampling on 8/18/97 and Yb concentration in cow feces.

d. Linear relationship between total time at the tank 2 d prior to Yb sampling on 8/25/97 and Yb concentration in cow feces.

Figure 5. Linear relationships between time at the tank and fecal Yb concentration (by sample day) of cows and calves grazing improved summer pastures.

Time at the tank was linearly related to fecal Yb concentration; however, the predictive power of the relationship is limited. Predictive capability may be limited due to varying rates of consumption of individual animals, or by differences in the proportion of time spent consuming while under the antennae. Calves and cows averaged 18 and 46 % of the time consuming when they were underneath the antennae. Putnam et al. (1968) reported that in an individual pen-fed situation, time spent at the bunk was related to the amount of feed consumed; however, cattle spent 94 to 97 % of their time at the bunk actually eating. Sowell et al (1995) reported that total minutes animals spent using supplement from a supplement feeder with 2 lick wheels was linearly related to supplement consumption as determined by fecal Yb concentration ($P < .05$; $R^2 = .51$). However, providing supplement in a lick-tank that only dispensed $1 \text{ kg supplement} \cdot \text{hd}^{-1} \cdot \text{hr}^{-1}$, improved the linear relationship to $R^2 = .71$ (B. F. Sowell, unpublished data). Restricting the amount of supplement available increased competition between animals and strengthened the relationship between time and intake.

Spearman's rank correlation coefficient between supplement intake and time at the tank (min/d) was .43 for calves and .41 for cows and supplement intake rankings were associated ($P < .10$) with the ranks of time at the feeder. Wilcoxon's signed ranks test indicated that the distribution of ranks of supplement intake and time were not different at the .10 alpha level indicating that both methods ranked supplement use similarly.

Chi-square analysis of contingency tables indicated that supplement intake and time at the tank (min/d) categorized calf use of the feeder in a similar manner ($P = .06$).

Supplement intake and time at the tank categorized 62 % of cows identically; however, the classifications were independent of each other ($P = .14$).

Conclusion

Calves spent the same amount of time at the supplement feeder as cows. Older cows spent more time (min/d and min/bout) at the feeder than younger cows; however, there was no difference in the frequency of visits between age groups. There was a linear relationship between time spent at the tank and supplement intake; however, time is not a good predictor of intake. Time at the tank can be used to rank supplement consumption by cows and calves, and can also be used to classify calves as medium or low consumers of supplement.

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SUMMARY AND IMPLICATIONS

This is the first study to report individual liquid supplement intake by suckling calves. Calves consumed equivalent amounts of supplement, on a % BW basis, and spent the same amount of time at the supplement feeder as mature cows. Therefore, additional nutrients can be supplied directly to grazing calves.

Late summer supplementation improved weight gains and forage intake by cows and calves. This level of response to supplementation was not expected given the quantity and quality of forage available and the purebred genetics of the herd. The majority of the literature documents improvements in calf performance of cows and calves that had access to liquid supplements post-calving and prior to weaning. This study was unreplicated and confounded by age of cow; however, yearly differences in forage quality are less dramatic on improved pastures compared to native pastures. It was not possible to determine how much of the increase in weaning weights of supplemented calves could be attributed solely to supplementation versus forage quality and herd genetics. Supplementation did not increase the amount of milk available to the calf; however, increased milk production due to supplementation would not be expected at this stage of lactation when milk production is declining. The literature also shows that there is not a strong relationship between calf ADG and milk production at this time of year. It seems probable that liquid supplementation increased forage intake and supplied additional protein that enabled supplemented calves to gain more than unsupplemented calves that were protein deficient. Level of calf response to supplementation could vary

depending on herd genetics, forage quality, pasture size and topography, stocking rate and location of the supplement feeder within the pasture.

Liquid supplementation was cost effective given the observed increase in calf gains and market cattle prices during the time this study was conducted. Level of animal response, supplementation costs and market cattle prices will influence profitability of liquid supplementation programs under different conditions. Future research should be directed toward the effects of supplementation on calf growth and cow reproductive performance throughout the year.

Future research should also be directed toward development of better methods for estimating individual forage and supplement intake by grazing calves. Electronic records of time spent at the supplement feeder was not a good predictor of supplement intake; however, time spent at the feeder can be used to rank supplement intake by cows and calves from high to low. Time can also be used to classify calves as low or moderate consumers of supplement.

APPENDIX

Summary of Visual Observations

I observed a calf come to the tank alone once and another time two cow/calf pairs who were grazing together came to and left the supplement feeder together. Cows and calves usually visited the supplement tank as part of a group; however, the observer noted that cow/calf pairs did not always visit the tank together (Table 14).

Table 14. Type of visit made to the supplement tank by cows and calves grazing improved summer pastures.

Type of visit	Calf (n=61)	Cow (n=35)
Alone	3 %	6 %
Group	97 %	94 %
With dam/calf	25 %	43 %

I observed a couple cows come to the tank with 5 or 6 calves and also saw large groups of 10-20 animals who were grazing together come to the supplement tank together. As many as 30 animals were observed near the feeder at one time although not all were using the tank at once. On one occasion, 90 % of the herd was within 50 yards of the tank. When a large group came to the tank they would all come at the same time and then trickle off one by one till no animals were left. Sometimes a few new animals came to the feeder during that time, but groups seemed to use the tank in shifts. Some animals were at the tank for 20 minutes to an hour, while others walked by barely stopping to look at the supplement. When cattle decided to come to the feeder they headed straight for the it, and when they were ready to leave it was fairly obvious, they left rapidly and walked straight away. Sometimes an animal left and then returned to the tank several minutes later, but most did not return to the feeder within the hour after having walked away. The

cannulated cows were observed visiting the tank together. Several (5-6) animals were observed with their heads under the panels and consuming supplement at the same time. I would say cattle spent about 5 % of the time they are in the vicinity of the tank actually consuming supplement. It appeared that as time progressed calves took longer licks of supplement. Sometimes when cattle came to the tank they spent most of their time scratching and then consumed supplement, and on other occasions they started consuming supplement right away and then spent time loitering near the tank. Animals were observed scratching on panels, playing, lying and nursing while at the tank. The scene at the tank was usually pretty calm, but cows were seen butting or pushing other calves and cows out of the way. I also observed calves butting cows away from the feeder. Generally the animal being pushed did not leave the tank area but just moved to another side of the tank.

Pasture conformation and cover seemed to influence how cattle grazed the pasture and the proportion of time they spent in various areas of the pasture (Table 15).

Table 15. Time spent in different areas of improved summer pastures grazed by cows and calves.

Period	Area of pasture	% Time	Activity
Pasture 1 (7/28 - 8/12) (9/12 - 10/3)	North	7	Grazing, resting, tank
	Middle	39	Grazing
	South	21	Grazing, resting
	South trees	33	Resting
Pasture 2 (8/13 - 9/11)	East	15	Grazing, resting
	South	13	Grazing, resting
	West	4	Grazing
	North (tank)	42	Grazing, resting, tank
	Middle ridge	27	Grazing, resting

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