Calf Note #61 – Effect of Nutrient Intake on Growth in Beef Calves

NOTE: Feeding, management and growth of beef calves varies somewhat from the methods used to raise dairy calves. Typically, beef calves are reared on the dam and intake of milk is determined by the nutrition of the cow and her ability to make milk. The information below is a review of literature regarding the growth of calves as it relates to milk production in beef cattle. The text in this note was adapted from a project written by Mr. Louis Caldwell as part of a research project at the University of Tennessee in 1990.

Introduction

Ahunu and Makarechian (1987) observed that preweaning growth of beef calves was curvilinear with respect to age and has been reported by other workers (Woodward et al., 1989; Boggs et al., 1980; Totesek et al., 1973). Regression coefficients were utilized to align calf weaning weights to a 205-day basis. These observations suggest that when the growth of calves change, nutrition may be inadequate. Continued growth rate of calves is dependent upon non-milk nutrient sources, requiring digestive adaptation to permit the calf to digest, absorb and utilize alternate nutrient sources.

During the early preweaning period milk nutrients are a greater proportion of energy consumption than at weaning. Milk intake measured during the first 4 months reportedly explains a significant portion of the variation in 205-d weight of calves while milk consumption during the last 3 months did not significantly reduce residual sums of squares (Rutledge et al., 1971). Bailey et al. (1981) estimated that at 44 d of age, milk supplied 86% of the DE, whereas at weaning, milk supplied only 19% of the DE. This indicates that the calf utilized increasing amounts of forage in response to reduced milk intake and increased nutrient requirements. Forage DM intake, estimated as the difference between DE requirements and DE obtained from milk, rose from .5 kg/d at 44 d of age to 5.5 kg/d at weaning.

The partial efficiency of milk metabolizable energy (ME) for body weight gain has been estimated as 0.63 (Johnson and Elliot, 1972). An estimated 450 kg of forage DM would have been consumed by weaning. Calf DE requirements was assumed to be 26.3 and 56.0 MJ/d at 44 d of age and weaning, respectively. Correlations between milk yield and calf ADG decrease as lactation progresses (Melton et al., 1967). Many researchers have investigated the relationships between milk and non-milk consumption and resulting calf gains. Bartle et al. (1984) concluded that each kg of calf gain required 7.5 kg of milk and 2.3 kg of creep feed. However in a second trial, the authors observed that milk required per kg of calf gain increased to 11.3 kg. Increased creep feed intake tended to reduce calf gains. This observation was probably associated with decreased milk consumption. It was further determined that by 9 wk of lactation, dam milk production was inadequate to support calf growth.
By 13 wk postcalving calves required a nutritional supplement to milk (Richardson et al., 1978). Twelve kg of milk were required for each additional kg of calf gain. Analysis of the data produced the following regression equations describing preweaning calf gains:

CG (0-35 d) = 4.9 + 0.084 × milk intake
CG (35-91 d) = 0.0148 × MME + 0.0313 × SFME + 0.11 × CM(35) + 6.97
CG (91-180 d) = 0.0353 × MME + 0.0243 × SFME + 0.06 × CM - 7.94

where:

CG - calf gain
MME - milk metabolizable energy
SFME- solid food metabolizable energy
CM - calf mass

The level of preweaning milk consumption had no effect on calf gains from 180 to 330 d or from 220 to 330 days. Cows required 1.488 kJ of ME above maintenance to produce 1 kJ milk energy. One MJ of solid food ME given to the cow would produce 0.672 × 0.94 = 0.632 MJ milk ME. When consumed by the calf, this would lead to an weight increase of 0.0223 kg , similar to the gain produced by feeding 1 MJ of feed directly to the calf (0.0243 kg calf gain).

Calf growth is not always enhanced by consumption of non-milk nutrients. Boggs et al. (1980) observed that grass intake was poorly related to calf performance when the entire preweaning period was considered. By dividing the preweaning period into segments, grass intake was negatively related to ADG during the first 2 months. This suggests that calves consuming the most forage were probably not consuming enough milk to meet their nutritional needs and were attempting to compensate by eating more forages. During months 3 to 5, each additional unit of forage intake tended to improve calf gains by 0.02 kg/d. Milk intake had a negative effect on forage intake, which was in agreement with et al. (1976b) and Wyatt et al. (1987). Davis et al. (1983), Marshall et al. (1976) and Bowden (1980) observed that calves compensated for lower dam milk production level by consuming more creep feed.

Richardson and Oliver (1979) observed that milk intake depressed solid food DM intake 0.93g/g milk DM intake for 44 to 60 d of age. From 72 to 88 d of age solid food DM intake decreased 1.89 g/g milk DM. Calves required 10.7 kg of milk/kg gain from 0 to 35 d of age and 14.3 kg of milk/kg gain during the period 35 to 91 d of age. Differences in observed quantity of milk for calf gain was due to maintenance energy requirements.

Sowell et al. (1988) restricted the nursing of calves to the anterior quarters of the udder for 2 and 4 weeks. Calves restricted for 2 weeks gained less during the restriction period. ADG were not different by weaning. Calves restricted for 4 weeks weighed 12.7 Kg less at weaning. Organic matter intake was similar in calves restricted for 4 weeks as compared to control calves for the entire period.

Wright and Russel (1987) reported a negative relationship (-0.87) between milk and forage intake of calves. Calves evidently altered forage intake in response to milk intake. Forage DM intake was not sufficient to compensate for restricted milk intake, resulting in reduced calf growth.

Attempts have been made to identify calf responses to varying levels of milk intake by offering milk according to lactation curves of beef cows. Abdelsamei et al. (1988) assigned forty Holstein steers to 5 lactation curves at birth. Chopped alfalfa hay was offered for ad libitum consumption 200 days.

Peak milk yield of the 5 lactation curves ranged from 2.72 to 13.6 kg. Calves receiving the low level of milk gained significantly less weight preweaning and similar amounts weight postweaning. However, they were unable to fully compensate to final slaughter weight. Similarly, Everitt and Jury (1977) noted that restriction in growth resulting from the consumption of a limited quantity of milk during early development persisted unchanged from weaning (150 d) to 330 d.

Broesder et al. (1988) fed 12 rumen cannulated Holstein calves milk according to a standard lactation curve for Angus-Hereford cows, or at 30 or 60% reduction in the standard lactation curve. A non-milk source of nutrients was provided by long stem alfalfa hay. Reduced milk consumption increased forage organic matter intake when expressed as a percent of body weight. However, total organic matter intake (milk plus forage) did not differ among the treatments. Reduction in milk intake reduced calf performance but tended to cause an earlier stabilization of rumen fermentation. Knapp and Black (1941) found a tendency for calves that consumed more milk to consume the less hay and grain.

Composition of milk has been suggested as an important source of variation in calf performance. Christian et al. (1965) observed that total butterfat and solids-not-fat accounted for more of the variability in weaning weight and preweaning gain than total milk intake during this period. A positive relationship between milk intake and dry feed intake existed when considering the entire preweaning period indicating the influence must be through increasing the capacity of the calf to consume feed.

Environmental conditions such as drought has spurned interest in management of early weaned beef calves. In a study to evaluate energy requirement of early weaned calves Harvey and Burns (1988) used NRC (1984) TDN requirement of a 182 kg calf gaining 0.67 kg/d of 3.14 kg. They assumed that 40-60% of the calves daily energy requirement is derived from forage. A total of 1.88 to 1.26 kg of TDN would be provided by milk at this calf weight. Early weaning practices would need to supply the quantity of nutrients available from milk.

Consumption of milk reduces the ability of the calf to utilize forage as a source of nutrients. Lusby et al. (1976) observed that milk intake was negatively correlated with cellulose digestibility, and with creep and forage intake. Creep intake of drylot calves, and cellulose intake of range calves, was positively correlated with cellulose digestibility and with calf metabolic weight ($BW^{0.75}$). The lower proportion of non-milk to milk nutrients in the diet reduced the overall efficiency of heavier weaning weights from increased milk production.

Davis et al. (1985) reported that an increase in milk production would improve the efficiency of slaughter weight production in cows producing less milk. Milk production was negatively related to efficiency of slaughter weight production of high producing cow, suggesting that cows were producing milk at a level calves could not utilize for gains.

Holloway et al. (1975) noted that Holstein progeny were less efficient in converting milk DE and total DE (milk and creep) to weaning weight than Hereford or Hereford X Holstein progeny. As milk consumption increased, efficiency of calf gain decreased. A threshold exists for milk consumption above which utilization of non-milk nutrients may be impaired (Stobo et al., 1966: Otterby and Rust, 1965; Warner et al., 1956). Stobo et al. (1966) observed greater ruminal development in calves offered dry feed with milk than in calves receiving little or no dry feed. With advanced development of the rumen, calves acquired greater utilization of dry feed as a nutrient source.

Calves appear to be able to select higher quality forage than cows. Ansotegui et al. (1988) observed grazing calves selected diets higher in crude protein than cows. This would tend to indicate calves are more adept to selecting the leaves, which contain a greater proportion of CP, than stems. As the grazing season progressed and fibrous fractions of forages increased, calves consumed diets lower in ADF and NDF. Apparently calves improved diet selection as grazing experience increased.

To continue previous growth pattern expressed at lighter body weights, digestive development must occur such that the calf can digest, absorb, and utilize nutrients available from forages and creep feeds. For the developing animal to benefit from rumen fermentation, end-products of microbial fermentation must be absorbed across the epithelial layer of the rumen wall. However, the complex relationships that exist between the source and quantity of nutrients and growth and digestive development of the preweaned beef calf at pasture are not clear.

Thomas and Hinks (1983) concluded that the main function of roughage in calf diets was to increase buffering capacity in the rumen. Roughage also facilitates a fermentation pattern more conducive to papillary growth. A greater amount of chopped straw at 20 mm length was required in the diet of early-weaned calves to promote the same buffering capacity and changes in molar % of VFA as the unchopped long straw. This effect resulted from an apparent decrease in rumen motility.

Thivend et al. (1980) stated that the extent of VFA absorption from the rumen is dependent on production of VFA within the rumen. Williams (1987) suggested that in the early stages of dry food intake, absorption of VFA from the rumen is unable to increase to compensate for increased production, a result of the underdeveloped state of the rumen epithelium. High rates of production would result in a depression of rumen pH. Rapid fermentation of cereal grains would produce lactate as an intermediate in the production of propionate, further depressing rumen pH. Williams et al. (1985) reported that pH of rumen contents is a major factor influencing voluntary food intake of calves.

Tissue Development of the Digestive Tract

Early differentiation of tissue into the forestomach of the bovine has been observed by 56 days in the fetus (Warner, 1958). By 120 days, tissue characteristic of each compartment of the forestomach are detectable. During early fetal development, growth is greater in the reticulorumen than in other compartments, revealing the evolutionary importance of this structure in digestion of cellulosic material. At birth the abomasum predominates in size and function, preparing the neonate for milk consumption (Becker et al., 1951). Bell et al. (1984) suggested that plasma gastrin concentrations are responsible for the structural and functional development of the gut in the fetal lamb. A linear increase in fetal gastrin concentrations during gestation peaked in the neonate 24 hr after birth. Further growth of the digestive tract is in response to increased body size, but differences in growth and development of specific digestive organs appears to be regulated by diet.

Warner (1958) fed diets of either milk, grain or hay to neonatal calves. Calves were sacrificed at 0, 4, 7, 10, and 13 weeks of age. By 4 weeks the reticulorumen of calves receiving grain or hay were heavier than of calves receiving milk diets. Differences were more pronounced at later ages. Stobo et al. (1966) noted that increasing concentrate to hay ratio of the diet increased the weight of the reticulorumen and thickness and length of rumen papillae.

Sutton et al., (1963b) studied effect of diet on rumen metabolic activity in calves receiving either milk (M) or milk, hay and grain (MHG). Rumen tissue samples were collected at 16 weeks of age and incubated in Kreb-Ringer bicarbonate solution containing 200 μM of either sodium acetate, propionate or butyrate, or an equimolar mixture of the three salts. Rumen mucosa from MHG calves utilized 5.9, 29.6, 44.1 and 31.5 μM/100 mg dry tissue, while rumen mucosa from M calves utilized 2.9, 5.8, 4.7 and 5.8 μM/100 mg dry tissue for acetate, propionate, butyrate and the equimolar mix, respectively. In a companion study Sutton et al. (1963a) infused VFA salts into the rumen. Absorption of VFA from the rumen was similar at 14 weeks in MHG calves weaned at either 4, 8, or 13 weeks. No absorption of VFA occurred in M calves. Sander et al. (1963) investigated the stimulatory effect of sodium salts of acetate, butyrate and propionate infusion into the rumen of calves receiving a milk diet on the rumen mucosal development. Butyrate and propionate caused an increase development in rumen mucosa and papillary score.

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Written by Mr. Louis Caldwell, University of Tennessee
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