Effects of Age, Body Size, and Milk Production on Nutrient Requirements of the Cow Herd

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Introduction

It has been stressed, time and time again, that most commercial cow–calf producers should reduce their cost of production to improve profitability. The national average annual cost to maintain the brood cow is approximately $411, whereas in Florida, it costs only $296 (Cattle–Fax, 1998). However, optimal reproductive performance and lactational ability of the brood cow, as well as adequate growth rates of the calf are also critical determinants of economic profitability for the cow–calf operation. The average Florida calf crop (number weaned as a percentage of the number of cows exposed) is approximately 76% compared to the national average of 84% (Cattle–Fax, 1998). Florida calves also tend to be lighter at weaning (483 lb) compared to the national average (516 lb). Considering that feed typically accounts for more than 50% of the total cost of production and that adequate body condition is highly related to reproductive performance of the cow (Rae et al., 1997), nutrition is of paramount importance, economically.

Essential Nutrients

Upon reading any text regarding nutrition and feeding of the cow herd, you will find that all animals require 5 basic classes of nutrients to support the physiological functions associated with maintenance, growth, reproduction, and lactation. These nutrients include energy, protein, minerals, vitamins, and water.

Energy

Animals demand energy, and this need for energy will be met first and at the expense of other nutrients, if necessary. For example, if the energy requirement is not satisfied and protein is available, the animal will break down dietary protein to satisfy their energy needs before using it to meet their protein or amino acid requirements (Cecava, 1995). Additionally, the quantitative demand and subsequent total cost for energy exceeds all other nutrients in the diet. For example, according to the NRC (1984), an 1,100-lb lactating brood cow requires 12.3 lb total digestible nutrients (TDN; a measure of energy), 2.0 lb crude protein (CP), and only .06 lb calcium (Ca) and .05 lb phosphorus (P) daily.

The two main sources of energy in the diet are carbohydrates (starch and the fibrous components of the plant) and fats. Protein may also be used as an energy source when other sources are limiting, but this is an expensive and inefficient source of energy.

The first and primary function of energy is for the support of maintenance, which includes processes associated with body temperature regulation, metabolism, and normal physical activity (NRC, 1996). Seventy percent of the metabolizable energy intake of the mature cow is used for maintenance (Jenkins and Ferrell, 1983) and more than 90% of the energy required by the mature breeding bull is used for this function. Even the growing heifer uses nearly 40% of her metabolizable energy intake to meet maintenance requirements (NRC, 1996). The balance is available for productive function—growth, reproduction, and lactation. If the maintenance requirement for energy is not supplied by the feed, the animal will mobilize body tissue (Buskirk et al., 1992), and suboptimal body condition can negatively affect pregnancy rates (Rae et al., 1997).

Protein

Proteins are complex organic compounds composed of amino acids, which serve as the basic "building blocks" within the body. Deposition of protein is necessary for growth. Protein is a primary cell component, and protein is used by nearly every organ or system in the body as it is an essential constituent of hormones, enzymes, and genetic material. Protein is essential to life.

Various quantities of ingested feed protein are degraded by ruminal microorganisms to smaller peptides and amino acids. Some of these proteins, peptides, and amino acids may pass through the rumen and be absorbed directly by the small intestine. However, the vast majority are converted to ammonia and reconverted to microbial protein that will be later digested and absorbed by ruminants for their own usage. This is a relatively inefficient process, but it does allow older cattle to utilize nonprotein nitrogen (NPN) compounds such as urea to meet a portion of their protein requirement, provided there is adequate energy in the diet. Animals usually respond to NPN supplementation with improved performance provided the dietary TDN:CP ratio is greater than 7:1 (Moore et al., 1991).

For many years, nutritionists have formulated diets based upon CP. Crude protein is a measure of all nitrogenous compounds in a feed and is easily measured and estimates are readily available for most feedstuffs. Producers are also readily familiar with the terms and concept of meeting the CP needs of the animal.

The 1996 NRC Nutrient Requirements of Beef Cattle program also generates requirements for metabolizable protein. Metabolizable protein is defined as the true protein absorbed by the intestine, which is supplied by microbial protein and undegraded intake (bypass) protein. The metabolizable protein system is designed to account for the protein or nitrogen needs of the microbes as well as the protein needs of the animal (Ensminger and Perry, 1997). However, there is limited information for many feedstuffs regarding their percentage of degradable and undegradable intake protein.

Minerals

At least 17 minerals are required by beef cattle (NRC, 1996), but many of the minerals are supplied in sufficient quantities by forages and other commonly used feedstuffs. However, deficiencies of phosphorus, salt, copper, cobalt, and selenium have affected beef cattle throughout Florida (Kunkle, 1996). An adequate mineral supplement should be offered free-choice at all times.

Vitamins

Many of the water-soluble (B-complex and vitamin C) and fat-soluble (A, D, E, and K) vitamins are physiologically required by ruminants. Several of the B vitamins function as cofactors in metabolism, and vitamin A is essential for normal growth and reproduction. Vitamin D is important for calcium and phosphorus absorption, and vitamin E serves as an antioxidant.

Despite these important physiological functions of vitamins, their supplementation is usually of minimal concern. Bacteria in the rumen synthesize the water-soluble vitamins and vitamin K. Typically, beef cattle synthesize sufficient quantities of vitamin D in their skin from exposure to direct sunlight or by consuming sun-cured hay, and vitamin E is found in most green forages. Vitamin A may be synthesized from carotene present in quality forages. Vitamin A, however, is most likely to be deficient in cattle consuming low-quality, weathered forages or high levels of concentrates in the diet.

Water

Water is often the forgotten nutrient, but it is an essential component of life. At birth, the animal body is 65 to 85% water, and at maturity water makes up 45 to 60% of the body weight. Water facilitates the transport of nutrients and excreta and is important for the regulation of body temperature. Water also helps to maintain cell shape, provides lubrication for various joints within the body, and is metabolically active. If the intake of water is restricted, reduced feed intake and subsequent productivity will result. Animals can survive for only a short period of time without water. Mature, nonstressed cattle will consume approximately 10 to 14 gallons per head daily. During periods of stress, the intake of water is even more critical. Animals should always be allowed free access to plenty of clean, fresh water (Jurgens, 1997).

Life-Cycle Changes in Nutrient Requirements of the Cow Herd

Although all nutrients listed and discussed above are critically important for maintenance of a healthy cow herd that is reproductively sound and productive, the following discussions will focus on the effects that age, body size, and milk production have upon energy and protein requirements. Requirements for these two nutrients change dramatically throughout the life-cycle of the brood cow, and they represent the greatest economic cost of supplementation.

The 1996 edition of NRC's *Nutrient Requirements of Beef Cattle* no longer provides tables of nutrient requirements. The authors of this publication have recognized that numerous animal and environmental factors influence nutritional requirements. Obvious animal factors include breed type, age, body condition, mature body size, peak milk production potential, and physiological state of production. Some environmental factors that influence nutrient requirements include factors associated with heat and cold stress such as outside temperatures and wind speeds. The user of this program will input all pertinent information related to the specific cow herd and local environmental conditions so that the program may generate specific requirements for the cattle in question.

For the following discussions, the nutrient requirements for a "base" cow were generated. The data input represented a moderately conditioned, 1,200-lb brood cow producing 20 lb milk during peak lactation. Environmental stresses were negligible.

Effect of Age

Few studies have evaluated the effects of age upon nutrient requirements of the cow, and differences should be highly correlated with body weight. Amongst mature cows, age will likely have a minimal effect upon nutrient requirements. However, as one evaluates the overall nutritional program of the herd, age is a vital consideration because nutrient requirements will differ greatly between the replacement heifer, the bred first- calf heifer, and the mature cow.

For the first-calf heifer, inadequate size at first parturition may limit milk production and rebreeding during the first lactation, however, excess energy intake can have negative effects on mammary development (NRC, 1996). Many researchers have collected data to support the concept of a genetically determined threshold age and weight at which bulls or heifers obtain puberty (Dunn and Moss, 1992; Patterson et al., 1992; Schillo et al., 1992). When developing heifers (Figure 1) to calve at two years of age, it has been recommended that heifers weigh 60 to 65% of their mature weight by 15 months of age. As a rule of thumb, this usually requires a targeted average daily gain of approximately 1.0 to 1.5 lb/d postweaning. Rates of growth may slow after breeding, but fetal growth during the third trimester of pregnancy is substantial and will prove to be a nutritional drain upon the first-calf heifer (Figures 2 and 4). Postpartum, first-calf heifers should weigh approximately 80% of their mature weight.

It is often said that replacement heifers have greater nutritional requirements than all other females in the herd because they are young and still growing. Figure 3 shows how the energy requirements (Mcal/d of NE_m) of a weaned calf and her mother change throughout the year postweaning. Requirements for both the mature cow and the replacement heifer are based upon a Brangus cow with a mature weight of 1,200 lb and 20 lb peak milk production.

At weaning, the replacement heifer requires 6.72 Mcal/d, whereas the gestating dam requires 8.95 Mcal/d. The mature cow would be in her second trimester of gestation, and fetal growth would be minimal at this time. Thus, the primary reason for the difference in energy required is the relative difference in body weight between the two females. As the mature cow approaches parturition, her requirements for energy are approximately 13.53 Mcal/d. Requirements for the 12-month-old replacement heifer are now 8.22 Mcal/d as a result of increased body weight associated with the heifer development program. At the time of breeding, the mature cow produces approximately 20 lb milk as she approaches peak lactation, and as a result, her energy requirement exceeds 16 Mcal/d, which is more than double the daily requirement of the replacement heifer at the time of breeding. Not until the mature cow has weaned her second calf and stopped lactating do the daily requirements for energy of the bred replacement heifer exceed energy requirements of the mature cow (Figure 3).

Figures 2 and 4, respectively, partition the net energy and metabolizable protein requirements of the bred heifer into maintenance, growth, and fetal development. As shown, fetal development during the third trimester of gestation provides a nutritional drain upon the first-calf heifer. The fetal portion of the heifer's net energy requirement increases from 1.07 to 4.88 Mcal/d (Figure 2) during the third trimester of gestation. Similarly, the fetal portion of the heifer's metabolizable protein requirement increases from 45 to 227 g/d (Figure 4).

Relative changes in the metabolizable protein requirement of the replacement heifer compared to the mature cow at the same point in time is shown in Figure 5. Differences and changes in daily protein requirements of the two individuals parallel those changes already discussed relative to the energy requirements.

However, the statement that replacement heifers have greater nutritional requirements than mature cows is not entirely false. To meet the daily requirements of a particular animal, one must consider the expected dry matter intake of that animal. Because replacement heifers cannot consume as much feed on a daily basis, nutrient density (Figures 3 and 5) of the replacement heifer diet must be greater than that for the mature cow. As the heifer gains body weight and dry matter intake increases, the percentage of protein (Figure 5) and other nutrients in the diet may be reduced.

Effect of Body Size

As the beef industry debated a change in body type during the early 70s, Klosterman (1972) stated that increased body size simply increases maintenance requirements. However, if adequate feed is available to support growth and reproductive performance is similar, Wagner et al. (1984) reported no significant associations between measures of mature cow size and efficiency of the pair at weaning. The primary issue for the cow–calf producer is feed availability and the matching of his/her environmental resources to the genetic demands of the cattle. Therefore, it is important to understand the effect of increased body weight on energy and protein requirements.

As mentioned previously, TDN is a measure of energy and is often expressed in lb or as a percentage of the ingredient or dietary dry matter. Although it may not be as precise as the net energy system commonly used for growing cattle, forage TDN values are easily determined and readily available. Therefore, the TDN system is commonly used for grazing cattle (Kunkle, 1996).

Figure 6 provides a compilation of the TDN requirements (daily basis) for 1,000-, 1,200-, and 1,400-lb mature Brangus cows that produce 20 lb milk during peak lactation. At the time of calving, 1,200- and 1,400-lb cows require 16 and 32% more TDN, respectively than 1,000-lb cows. The increased demand for energy due to greater body weight is relatively constant across all phases of the beef production cycle.

Figure 7 shows the effect of body size on CP requirements of the mature cow. A 1,000-lb Brangus cow producing 20 lb milk during peak lactation requires 1.86, 2.80, and 1.26 lb CP at the time of calving, breeding, and weaning, respectively. Again, every 200 lb body weight increased the protein requirement of cows at parturition by 16% compared to the requirements of a 1,000-lb cow.

Effects of Milk Production

High levels of milk production are necessary if one wishes to maximize weaning weights. However, there is a nutritional cost for increased milk production and potentially increased revenue from the sale of heavier calves at the time of weaning. Maintenance requirements for energy of lactating cows are 38 to 41% greater than for non-lactating cows (Neville, 1974).

Figure 8 shows the effect of milk production on the TDN requirements of a mature, 1,200-lb Brangus cow. As shown, a low level of milk production (10 lb/d) does not have a major impact upon the nutrient requirements of the cow. However, as peak milk production increases above 10 lb, the daily TDN requirement (approximately 2 months postpartum) increases nearly 20%. The cow producing 10 lb milk requires 13.94 lb TDN, whereas the cow that produces 20 or 30 lb milk during peak lactation requires 16.65 and 19.34 lb TDN, respectively.

When the calf is weaned, and the cow is dry, requirements for energy are at their lowest point during the year for a productive mature cow. Comparing the requirements for TDN at 2 and 7 months postpartum, one can see the effect of lactation compared to that of the dry cow. A low level of milk production (10 lb) increases the energy requirement of the lactating cow 28% compared to that of the dry cow. If the cow produces 20 or 30 lb milk during peak lactation, the TDN requirement is 53 and 78% greater than that for the dry cow, respectively. It is imperative that producers optimize genetic potential for milk production relative to the available feed resources so that optimum body condition can be maintained and sound reproductive performance sustained.

Changes in the requirement for CP by the cow throughout her productive cycle (Figure 9) parallel the changes already discussed for energy. For the 1,200-lb Brangus cow, every 10 lb milk production increases the daily CP requirement 35% during peak lactation, which should correspond closely with the scheduled breeding season.

Implications

Nutrient requirements of the cow are affected by many variables. Still, we know that increased body weight and milk production increase the demand of the body for both energy and protein as well as other minerals and vitamins. To maintain adequate body condition and sound reproductive performance, it is imperative that we evaluate and consider changes in nutrient requirements of the cow herd when making management decisions.

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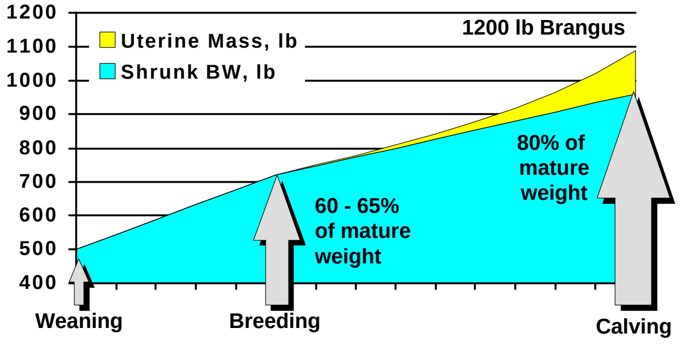
Figure 1. Body weight changes of the replacement heifer.



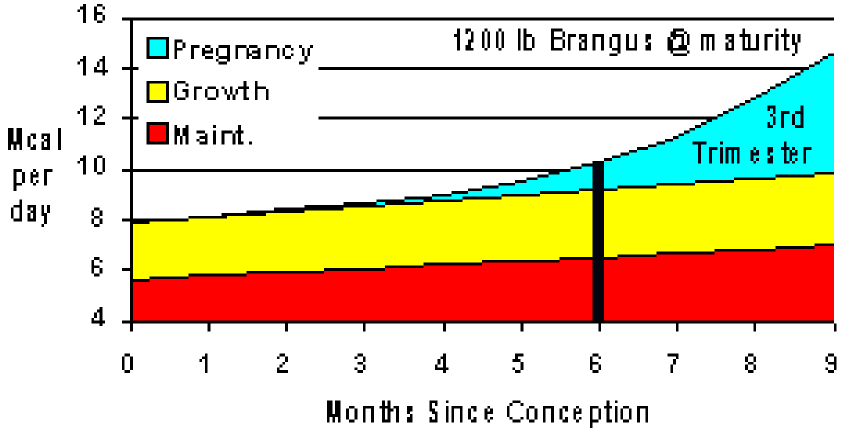


Figure 2. Net energy requirements of the replacement heifer during gestation.

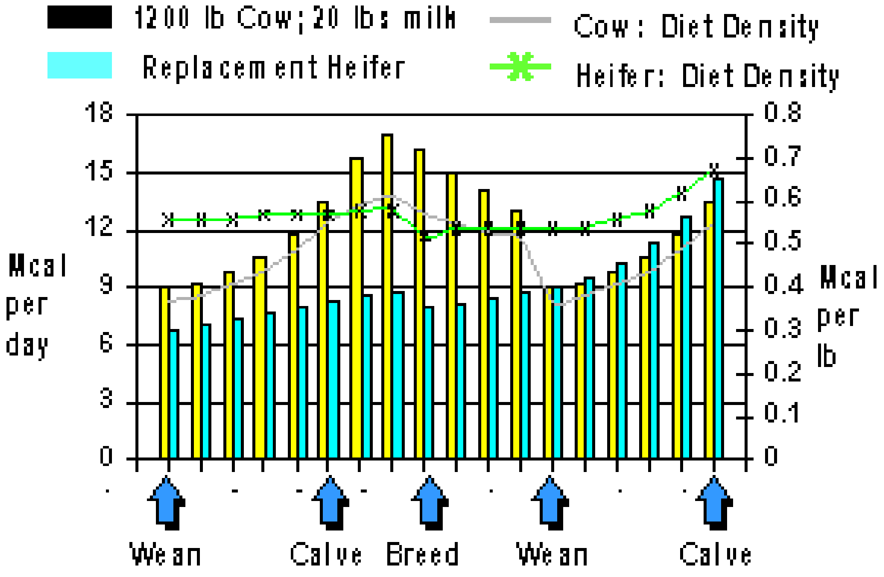


Figure 3. A comparison of the net energy requirements of cows and heifers.

Figure 4. Metabolizable protein requirements of the replacement heifer during gestation.

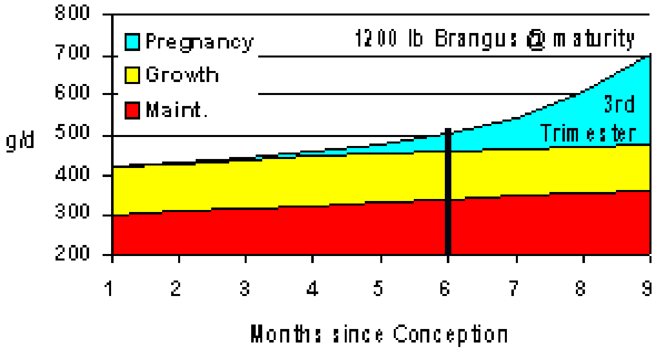


Figure 5. A comparison of the protein requirements of cows and heifers.

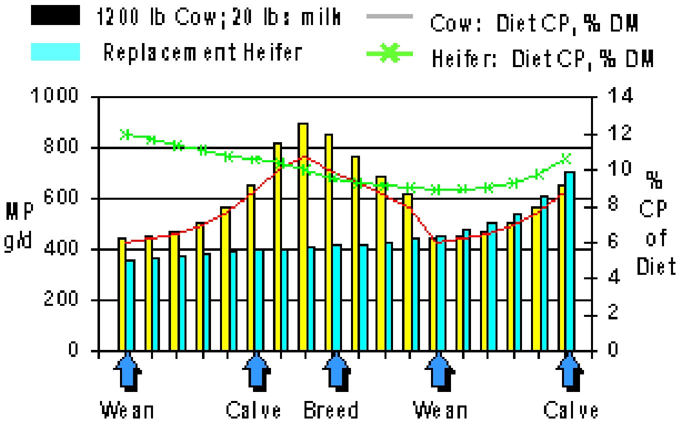
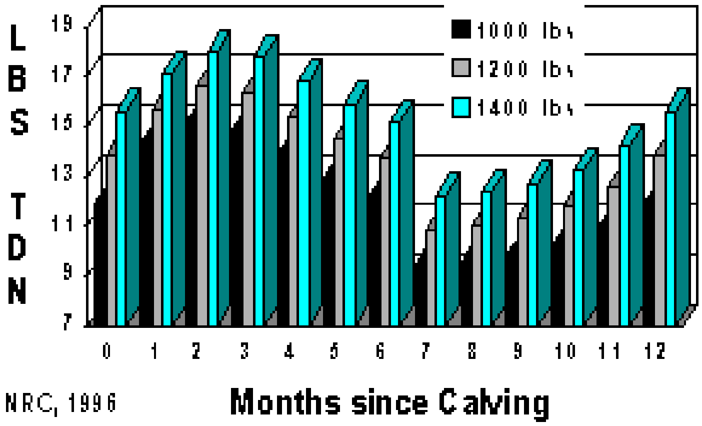
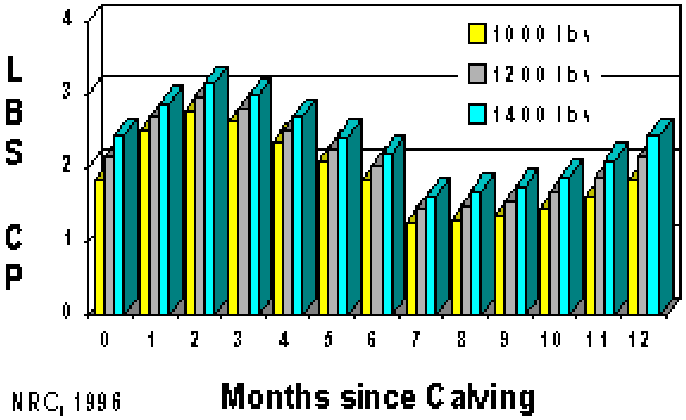


Figure 6. Effect of mature body size on the daily TDN requirements of beef cows.



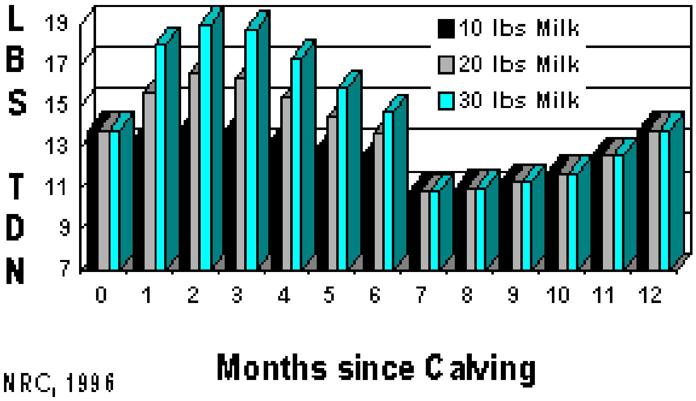
NRC, 1996

Figure 7. Effect of mature body size on the daily CP requirements of beef cows.



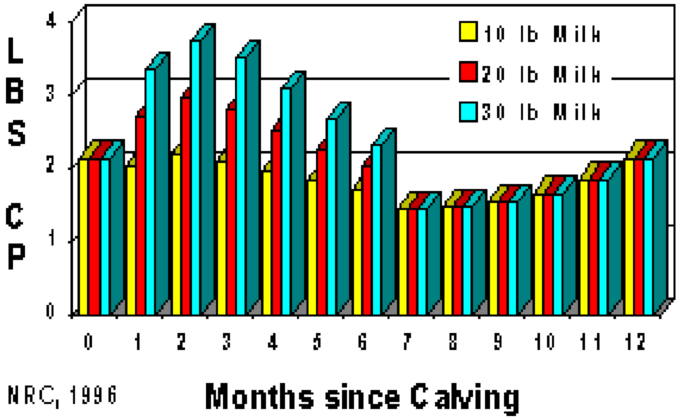
NRC, 1996

Figure 8. Effect of milk production on the daily TDN requirements of mature beef cows.



NRC, 1996

Figure 9. Effect of milk production on the daily CP requirements of mature beef cows.



NRC, 1996