MANAGEMENT

Repro Tracks

▸ by **Cliff Lamb,** University of Florida

Fetal programming

The theme of this issue of the Angus Journal *is genomics, so I thought I would focus this column on something somewhat related to genetics (although not entirely genomic-centered), which is fetal programming. Fetal programming is a term that many producers may have heard of in recent years, but they may not understand the concept. My goal is to answer some questions that may help readers understand the concept in more detail.*

Genetics and reproduction

What does fetal programming mean?

The concept of fetal programming, also known as developmental programming, was first introduced in humans and referred to as "the Barker hypothesis." Essentially, this concept states that during critical prenatal development stages, lasting impacts on postnatal growth and adult function may occur.

Fetal growth is thought to be set at an early stage in development and environmental insults may alter subsequent functions such as growth, health and reproduction. These functions appear to be caused by epigenetic (nongenetic influences in gene expression) changes in gene expression in the embryo leading to further changes in fetal development.

From a cattle standpoint, many factors influence livestock nutrient requirements, including breed, season and physiological function. Fetal programming responses can result from a negative nutrient environment, which can be caused by

- breeding of young dams who compete for nutrients with rapidly growing fetal systems;
- increased incidences of multiple fetuses;
- selection for increased milk production, which competes for nutrients with increased energy demand from fetal and placental growth; or
- breeding of cattle during high environmental temperatures and pregnancy occurring during periods of poor pasture conditions.

It has been reported in research that compromised maternal nutrition during gestation resulted in increased calf mortality, intestinal and respiratory dysfunction, metabolic disorders, decreased postnatal growth rates, and reduced meat quality. Therefore, nutritional management of cows during gestation may enhance performance and health of calves.

How might nutrient restriction during gestation affect fetal development?

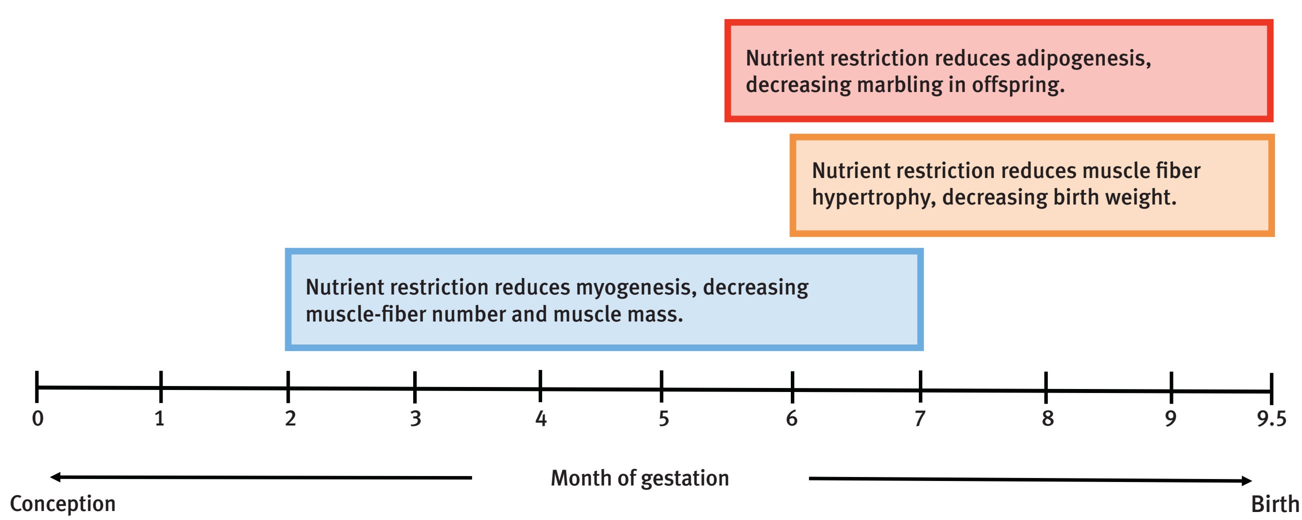
A majority of fetal growth occurs during the last two months of gestation. However, during the early phase of fetal development, critical events for normal conceptus development occur, including differentiation, vascularization, fetal organogenesis and placental development.

The fetal organs develop at the same time as development of the placenta and limbs, which start as early as Day 25 of gestation. Following limb development is a sequential development of other organs, including the pancreas, liver, adrenal glands, lungs, thyroid, spleen, brain, thymus and kidneys. In male calves, testicular development is initiated by Day 45 and ovarian development begins in female fetuses by Day 50.

Therefore, with functional organs developed early in fetuses, adequate blood flow and nutrients to the fetus are critical for further development.

The fetal stage is also crucial for skeletal muscle development because muscle-fiber numbers do not increase after birth. Skeletal muscle is a lower priority in nutrient partitioning compared with the brain, heart or other organ systems, making it particularly

Fig. 1: Stages of fetal development of muscle and adipocytes that may be affected by nutrient restriction in cattle



Source: Du et al., 2010.

vulnerable to nutrient deficiency. Thus, a decrease in nutrient availability to the dam during gestation can result in a reduced number of muscle fibers through fetal programming, reducing muscle mass and impacting animal performance.

Both muscle-fiber number and intramuscular adipocytes, which provide the sites for intramuscular fat accumulation or marbling formation, are influenced during fetal development. Fig. 1 demonstrates where nutrient restriction during gestation may impact muscle and adipocyte formation and subsequent fetal and calf development. The approximate ranges depicted in the figure are estimated mainly based on data from studies in sheep, rodents and humans, and represent the progression through the various developmental stages summarized by Du et al., 2010 in the *Journal of Animal Science,* 88 (E. Suppl.):E51-E60.

How is subsequent calf performance affected by nutrient restriction?

A few studies have demonstrated the link between maternal nutrition and subsequent offspring performance. One study indicated that steers from dams who had been nutritionally restricted during gestation had reduced body weights, and carcass weights at slaughter were also reduced.

In addition, calves from cows who had been provided supplemental protein during gestation had increased birth weights, which indicates a potential alteration in fetal muscle growth. Similarly, when cows received protein supplementation in late gestation, calves from supplemented cows had increased adjusted 205-day weaning weights, prebreeding weight, weight at pregnancy diagnosis, and improved pregnancy rates compared to heifers from dams who did not receive protein supplementation.

Another advantage noted was that heifers from cows that received supplemental protein during late gestation also had a decreased age at puberty and tended to have greater breeding-season pregnancy rates compared to heifers from nonsupplemented dams. Therefore, it appears that nutritional management during gestation may have implications on subsequent calf development.

What influence does maternal nutrition have on subsequent calf health?

Proper maternal nutrition during gestation appears to enhance calf health. For example, research has shown that increased morbidity and mortality rates in calves born to females receiving 65% of their dietary energy requirement during the last 90 days of gestation compared to calves from females receiving 100% of their energy requirement. One factor contributing to increased morbidity and mortality is decreased birth weight. Calves born to nutrient-restricted dams were 4.5 pounds lighter at birth compared to calves from dams receiving adequate nutrition.

Therefore, management of the maternal diet beginning during early gestation will ensure proper placental programming resulting in adequate nutrient transfer to the fetus. Maternal nutrition later in gestation appears to influence fetal organ development, muscle development, postnatal calf performance and reproduction. Although the mechanisms by which placental and fetal programming occur are not clear, managing resources to ensure proper cow nutrient intake during critical points of gestation can improve calf performance and health.

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