Western Beef Resource Committee

Fourth Edition

Cattle Producer's Handbook

Nutrition Section 385

Fetal Programming and Its Effect on Growth, Carcass Composition, and Reproductive Performance of Ruminants

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What is Fetal Programming?

"Fetal programming" is the theory that **the environment an animal is exposed to *in utero* and/or early in life affects its development and impacts its health and performance later in life**. Livestock producers have long known that keeping the pregnant cows well nourished and healthy is important for the successful birth of live, healthy calves. Despite this, beef cows often graze poor quality winter range or are fed low quality hay during gestation, which usually do not meet the dam's nutrient requirements for maintenance and growth of the fetus. Research on fetal programming in livestock is growing and is demonstrating the importance of providing proper nutrition during gestation to allow for optimal fetal growth and development.

Nutrient Demands of Pregnancy

Nutrient requirements increase dramatically in mid- and especially late gestation due to rapid fetal growth. For example, the energy requirements (NE_m requirements) of a 1,200 pound beef cow increases from 9 Mcal NE_m /day on day 120 of gestation to 13.5 Mcal NE_m /day on day 270 of gestation (Fig. 1). During this time, the proportion of total energy requirements that goes to fetal growth increases from less than 4 percent at day 120 to 38 percent on day 270 of pregnancy. Protein requirements increase similarly to energy requirements during pregnancy. Thus, when weaning occurs and nutrient requirements decrease because lactation ends, nutrients needed for gestation are increasing.

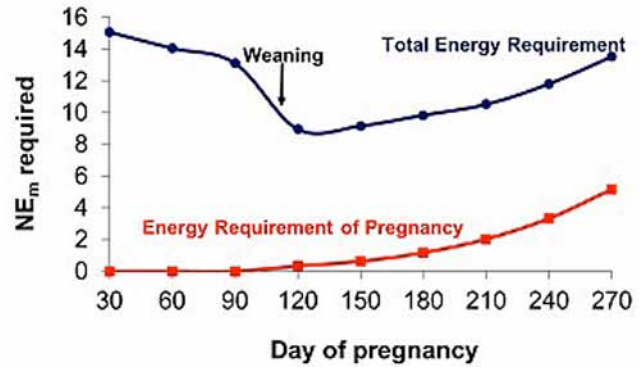

Fig. 1. Beef cow energy requirements of pregnancy.

Critical Periods of Development

Cows that are under-nourished during gestation will partition nutrients to the developing fetus, even utilizing body stores of fat and protein to protect the fetus, but this has its limits. When nutrient requirements are not met during gestation or nutrients are diverted to growth (growing heifers) or lactation (early gestation), fetal growth may be impaired. The implications of limited nutrient availability to the fetus vary based on the period in which restriction occurs during gestation and/or neonatal life.

The first weeks after breeding are important for embryo development and recognition of pregnancy by the cow. The placenta, the site for fetal and maternal attachment and nutrient and waste exchange during gestation, begins to develop during this period, then has rapid growth in early to mid-gestation. The organ systems of the fetal calf form and begin to develop during early to mid-gestation then grow rapidly as the calf increases growth in late gestation. The time immediately around birth and early calf life are both important for the final maturating of organs to prepare the calf for life outside of its dam.

Recent research indicates that nutrition during gestation impacts milk production of the cow and ewe as well, even when her nutrient requirements are met postpartum. This means that effects of nutrition during pregnancy can extend past calving and decrease the

amount and quality of milk produced, further affecting growth performance and health of calves.

Impacts on Offspring

Depending on what nutrients are restricted during pregnancy (e.g., all nutrients, protein, or energy), and the period in which this restriction takes place, calf growth, development, health, and performance can be greatly affected. Calves from dams that have been nutrient restricted during late gestation typically have decreased fetal growth, which may result in lighter birth weights. These lower birth weights are not necessarily good, however, as low birth weights can mean poor development, increased sickness, and possibly death loss.

Whether birth weight has been decreased or not, nutrition of the dam during gestation can affect pre- and post-weaning growth of calves, leading to decreased weaning weights, heifer weights at breeding, and steer slaughter weights because of reduced average daily gain. Additionally, feed efficiency has been altered in some calves due to nutrition during gestation.

Altered growth and feed efficiency are not the only implications of nutrient restriction during pregnancy, however. Nutrition during gestation can affect many important organ systems in the body, which decreases or changes their functions in the animal. These changes that have been observed in beef cattle research include decreased carcass weight and yield, reduced marbling and carcass quality, decreased heifer reproductive performance, and poor health after birth and into the feedlot. A summary of these is listed in Table 1. Although much more research is needed to determine why these effects are present and how they may be reversed, it is apparent that nutrition of cows during pregnancy has many effects on calves.

Summary

Fetal programming occurs in beef cattle, often because of maternal nutrient management during the critical periods of fetal or calf growth. Inadequate nutrition of the dam impairs calf traits such as growth, feed efficiency, health, reproductive performance, and carcass quality. Additionally, milk production of the dam may be impacted by nutrition during pregnancy, having further effects on nursing offspring. Consequently, nutritional management of beef cows should allow them to meet the increasing nutrient requirements due to fetal growth during gestation to prevent negative effects on calves.

References

Caton, J. S., and B. W. Hess. 2010. Maternal plane of nutrition: Impacts on fetal outcomes and postnatal offspring responses. pp. 104-122. *In* Proc. 4th Grazing Livestock Nutrition Conference. B. W. Hess, T. DelCurto, J. G. P. Bowman, and R. C. Waterman, eds. West Sec. Am. Soc. Anim. Sci., Champaign, IL.

Du, M., J. Tong, J. Zhao, K. R. Underwood, M. Zhu, S. P. Ford, and P. W. Nathanielsz. 2010. Fetal programming of skeletal muscle development in ruminant animals. J. Anim. Sci. 88:E51-E60.

Funston, R. N., D. M. Larson, and K. A. Vonnahme. 2010. Effects of maternal nutrition on conceptus growth and offspring performance: Implications for beef cattle production. J. Anim. Sci. 88:E205-E215.

Meyer, A. M., J. S. Caton, B. W. Hess, S. P. Ford, and L. P. Reynolds. 2012. Epigenetics and effects on the neonate that may impact feed efficiency. pp. 195-224. *In* Feed Efficiency in the Beef Industry. R. Hill, ed. Wiley-Blackwell.

NRC. 2000. Nutrient Requirements of Beef Cattle, 7th rev. ed. National Acad. Press, Washington, DC.

Wu, G., F. W. Bazer, J. M. Wallace, and T. E. Spencer. 2006. Intrauterine growth retardation: Implications for the animal sciences. J. Anim. Sci. 84:2,316-2,337.

Table 1. Impacts of nutrition during pregnancy on calf performance.

Trait affected	Effects of altered nutrition during pregnancy
Growth traits	Decreased average daily gain Decreased weaning weights Decreased breeding weights Decreased slaughter weights Altered feed efficiency
Carcass composition	Decreased hot carcass weight Decreased muscle mass Decreased marbling and quality grade Altered tenderness
Reproductive performance of daughters	Increased age at puberty Decreased conception and pregnancy rates Altered hormone production Decreased milk production
Health	Decreased calving and weaning rates Increased calf sickness Increased feedlot morbidity Increased mortality rates

Fourth edition; December 2016 Reprint