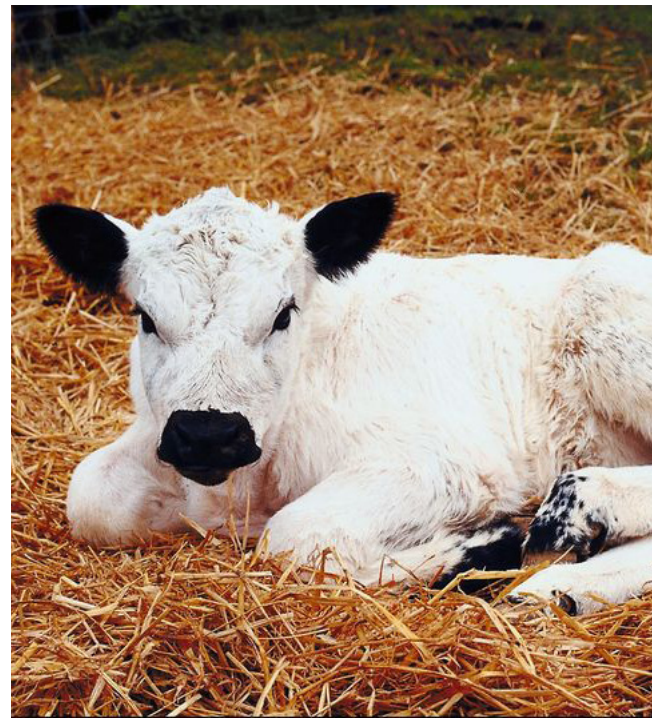


# Feeding Beef Cattle II: Fetal Programming—Rethinking Cow/Calf Feeding Programs

WASHINGTON STATE UNIVERSITY EXTENSION • EM060E



# Feeding Beef Cattle II: Fetal Programming—Rethinking Cow/Calf Feeding Programs

## Introduction

In the WSU fact sheet, Feeding Beef Cattle I, we examined forage nutrition and provided an introduction to forage quality and supplementation. In this WSU fact sheet, Feeding Beef Cattle II, we will take an in-depth look at the link between supplementing pregnant beef cows and subsequent growth and performance of calves.

Typically, beef cattle producers have two priorities when feeding beef cows 1) feeding them economically, and 2) preventing reproductive failure, with a focus on getting the cows through the production cycle with a live calf and getting them bred back and ready to repeat this process. To achieve these goals, producers assess the nutritional composition of their base forages and provide supplements to eliminate any nutritional imbalances that may be present (i.e., imbalances in protein, energy, minerals, and vitamins). At this point, from the producer's perspective, if nutritional requirements are currently being met, then, by convention, the cows and their progeny will likely perform well throughout the production cycle. However, science is providing greater insights into the implications of feeding programs and how these programs affect a calf well after it has been weaned.

## Systems Approach to Beef Cattle Management

Improving beef quality means working within a complex *system*. Beef cattle systems integrate biology, ecology, economics, and even human behavior (Dunn and Johnson 2010). For many years, beef cattle producers have adopted management and feeding practices and new technologies as they have become available. However, data suggest that taking the *big picture* approach may reap considerable benefits in both short- and long-term productivity.

## Science of Fetal Programming

*Fetal programming* is defined as maternal stimuli during pregnancy that can affect fetal development, as well as postnatal growth and health (Martin et al. 2007). This means that the way beef cows are man-

aged during pregnancy can have a significant effect on the growth and performance of their offspring later in life.

The effects of fetal programming can be seen in several of the production traits that are important to the economic viability of beef cattle operations. These traits include muscle and fat development, calf survivability, growth, carcass characteristics, reproduction, and health.

## Adequate Nutrition

Beef cattle have important nutritional requirements. In the WSU fact sheet Feeding Beef Cattle I, some of the available tools and resources for determining nutritional adequacy are provided. In beef cattle, body condition and weight loss that result in delayed return to estrus, reproductive failure, and weak calves can all be symptoms of poor nutrition. Vitamins and minerals play a significant role in the nutritional status of the beef cow, and deficiencies are manifested in a variety of ways, including problems with growth, metabolism, and reproduction. Recent research suggests that calves may be affected by the nutrition of the cow during pregnancy, and although these effects may not be apparent at birth, they may be manifested later in life.

## Muscle and Fat Development

In addition to the direct effects of management and environment on calf performance, recent investigations suggest that maternal nutrition (i.e., nutrition of the pregnant cow) may affect growth and performance of the offspring well after weaning. Meat animals are raised for their skeletal muscle, and the fetal stage is crucial for skeletal muscle development because there is no net increase in the number of muscle fibers after birth (Stickland 1978; Zhu et al. 2004). Consequently, a decrease in the number of muscle fibers due to fetal programming permanently reduces muscle mass and thus reduces animal performance (Du et al. 2010a). A reduction in muscle mass can ultimately reduce the amount of saleable beef product, thus holding important economic implications for the producer.

Marbling (intramuscular fat) is crucial for meat palatability, and fetal life is a major stage in developing intramuscular fat cells (Du et al. 2010b; Tong et al. 2008). These fat cells provide the sites for intramuscular fat accumulation or marbling formation during fattening. Hence, fetal programming also affects the marbling that takes place in cattle offspring. Mid-to-late gestation is critical for muscle fiber formation and growth, and late gestation is important for marbling development. However, because muscle and fat develop in slightly different stages of fetal development, nutrient deficiencies during pregnancy will have varying effects on fetal development and offspring performance.

### Relationship between Cow Nutrition and Calf Survivability

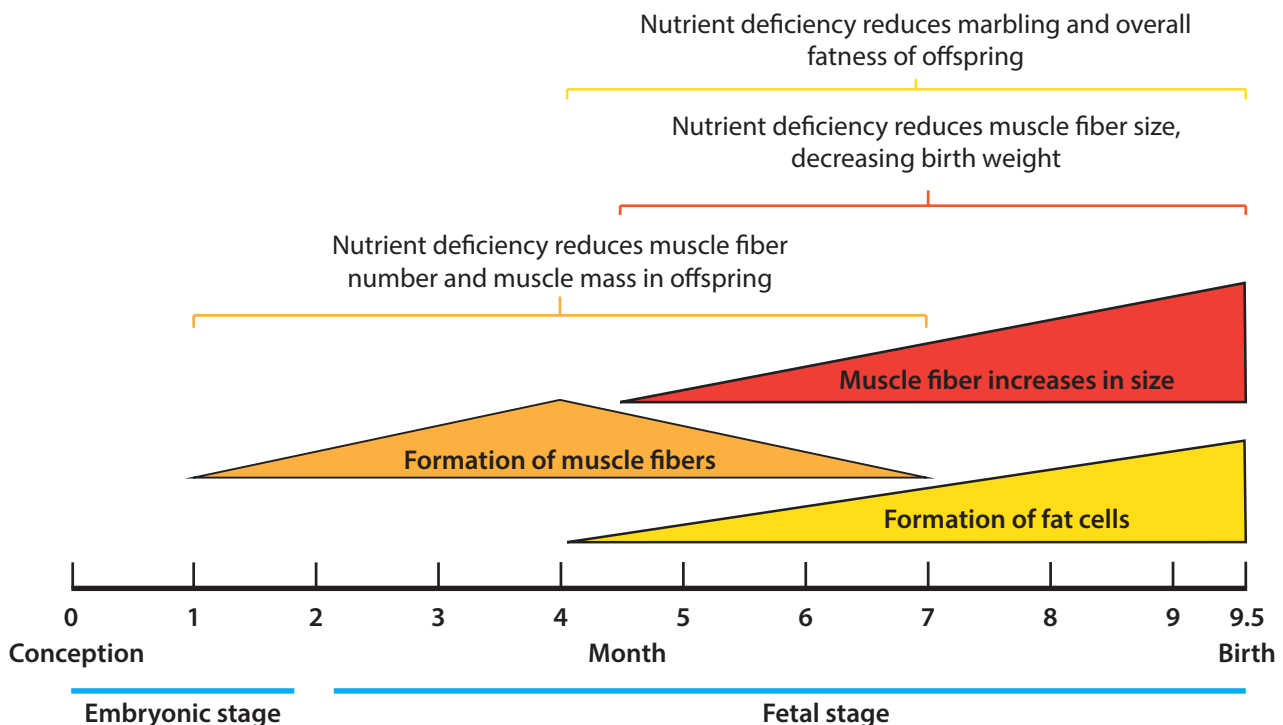
In terms of progeny health, maternal nutrition is related to calf morbidity and mortality (Corah et al. 1975). Nutritional conditions during critical periods in fetal development can ultimately affect neonatal health, as well as a cow's susceptibility to disease during later phases of beef cattle production. Inadequate fetal nutrition may also permanently affect postnatal growth of the offspring (Wu et al. 2006; Funston et al. 2010a).

### Growth and Carcass Characteristics

In a University of Nebraska study, cow herds grazing dormant range during the winter were divided into two groups. One group was given supplemental protein and the other was not. Study results showed that providing supplemental protein (in the form of a 42% protein cube delivered at a rate equivalent to one pound per day given three days a week) increased weaning weights by 22 lb and hot carcass weights by 87 lb. Supplementation also increased marbling scores (Stalker et al. 2007). In a similar experiment, cows grazed dormant range or corn residue during the winter and were given supplements equivalent to one pound per day of a 28% protein cube delivered three days a week. This supplementation resulted in a 17 lb increase in weaning weight, a 17 lb increase in hot carcass weight, and an increase in marbling scores of approximately 11% (Larson et al. 2009). These studies were conducted during the third trimester of gestation.

These findings are significant because increases in weaning weights and hot carcass weights (i.e., carcass weight at slaughter) contribute to the amount of saleable product, the amount of marbling within the loin eye, and maturity—factors that determine the USDA Quality Grade. Protein supplementation

### Fetal Development Timeline



at mid-gestation, a stage critical for muscle development, also enhances muscle growth and offspring performance (Du et al. 2010a; Underwood et al. 2008).

These results are important because weaning in a traditional system occurs approximately 10 to 12 months following the last trimester supplement. Considering the length of time between late gestation, birth, weaning, stocker/backgrounding, and finishing, the improvements in carcass traits is noteworthy and should be taken into account when making cow/calf management decisions.

## Reproduction

In a study investigating protein supplementation in cows grazing dormant range during late gestation, cows were given either a one-pound-equivalent of supplemental protein (in the form of a 42% protein cube delivered three days a week), or no protein supplementation. Heifers from dams receiving protein supplements were 17 lb heavier at weaning, and their pregnancy rate was increased by more than 16% (Martin et al. 2007). In a study in which dams were fed under similar protocols and conditions during late gestation, Funston et al. (2010b) observed a 12% increase in pregnancy rates and a reduction in the age at which calves reached puberty after they were provided with a 31% protein cube supplementation.

In terms of economics (e.g., the cost of purchasing or developing replacement heifers), to be able to document changes in heifer reproductive performance based on the nutritional status of their dams during pregnancy is a significant breakthrough in understanding the implications of beef cow feeding programs.

## Health

Several investigations into the effects of maternal nutrition on colostrum and passive transfer of immunity in calves have shown mixed results. However, Stalker et al. (2006) fed the equivalent of one pound of a 42% protein supplement per day to cows grazing native range during late pregnancy, and they reported a greater proportion of calves having been weaned. Larson et al. (2009) noted that the proportion of calves treated for respiratory or gastrointestinal disease did not differ between cows receiving supplements and those that were not supplemented during late pregnancy. However, from weaning to slaughter, the proportion of calves treated for respiratory or gastrointestinal disease was reduced for cows that received protein supplements in late gestation.

## Conclusions

The concept of fetal programming through maternal nutrition requires a rethinking of current beef cow feeding programs. Studies show that protein supplementation of beef cows during late gestation can influence muscle and fat development in the fetus, and in subsequent growth, it can influence carcass characteristics, reproductive performance of female progeny, and animal health. These influences can be observed many months following supplementation of the pregnant cow. Thus, fetal programming (with its effects on calf traits and performance) has significant economic implications for beef cattle producers. Also, given the relationship between fetal programming and maternal nutrition, new low-cost feeds entering the marketplace should be evaluated to determine their effects on fetal development and calf performance later in life.

## References

- Corah, L.R., T.G. Dunn, and C.C. Kaltentbach. 1975. Influence of Prepartum Nutrition on the Reproductive Performance of Beef Females and the Performance of their Progeny. *Journal of Animal Science* 41:819–824.
- Du, M., J. Tong, J. Zhao, K.R. Underwood, M. Zhu, S.P. Ford, and P.W. Nathanielsz. 2010a. Fetal Programming of Skeletal Muscle Development in Ruminant Animals. *Journal of Animal Science* 88:E51–60.
- Du, M., J. Yin, and M.J. Zhu. 2010b. Cellular Signaling Pathways Regulating the Initial Stage of Adipogenesis and Marbling of Skeletal Muscle. *Meat Science* 86:103–109.
- Dunn, B.H., and J.J. Johnson. 2010. Systems Approach to Beef Production. In *Proceedings of Beef Improvement Federation 42nd Annual Research Symposium and Annual Meeting* 12–21.
- Funston, R.N., D.M. Larson, and K.A. Vonnahme. 2010a. Effect of Maternal Nutrition on Conceptus Growth and Offspring Performance: Implications for Beef Cattle Production. *Journal of Animal Science* 88:E205–E215.
- Funston, R.N., J.L. Martin, D.C. Adams, and D.M. Larson. 2010b. Winter Grazing System and Supplementation of Beef Cows during Late Gestation Influence Heifer Progeny. *Journal of Animal Science* 88:4094–4101.
- Larson, D.M., J.L. Martin, D.C. Adams, and R.M. Funston. 2009. Winter Grazing System and Supple-

- mentation during Late Gestation Influence Performance of Beef Cows and Steer Progeny. *Journal of Animal Science* 87:1147–1155.
- Llewellyn, D. 2012. Feeding Beef Cattle Low-Quality Forage. *Washington State University Extension Publication* EM053E. <http://cru.cahe.wsu.edu/CE-Publications/EM053E/EM053E.pdf>.
- Martin, J.L., K.A. Vonnahme, D.C. Adams, G.P. Lardy, and R.N. Funston. 2007. Effects of Dam Nutrition on Growth and Reproductive Performance of Heifer Calves. *Journal of Animal Science* 85:841–847.
- Stalker, L.A., D.C. Adams, T.J. Klopfenstein, D.M. Feuz, and R.N. Funston. 2006. Effect of Pre- and Postpartum Nutrition on Reproduction in Spring Calving Cows and Calf Feedlot Performance. *Journal of Animal Science* 84:2582–2589.
- Stalker, L.A., L.A. Ciminski, D.C. Adams, T.J. Klopfenstein, and R.T. Clark. 2007. Effects of Weaning Date and Prepartum Protein Supplementation on Cow Performance and Calf Growth. *Rangeland Ecology and Management* 60:578–587.
- Stickland, N.C. 1978. A Quantitative Study of Muscle Development in the Bovine Foetus (*Bos indicus*). *Anatomia, Histologia, Embryologia* 7:193–205.
- Tong, J., M.J. Zhu, K.R. Underwood, B.W. Hess, S.P. Ford, and M. Du. 2008. Amp-Activated Protein Kinase and Adipogenesis in Sheep Fetal Skeletal Muscle and 3t3-l1 Cells. *Journal of Animal Science* 86:1296–1305.
- Underwood, K.R., J.M. Kimzey, J. Tong, P.L. Price, E.E. Grings, B.W. Hess, W.J. Means, and M. Du. 2008. Gestational Nutrition Effects Growth and Adipose Tissue Deposition in Steers. In *Proceedings of Western Section of American Society of Animal Science* 59:29–32.
- Wu, G., F.W. Bazer, J.M. Wallace, and T.E. Spencer. 2006. Board-Invited Review: Intrauterine Growth Retardation: Implications for the Animal Sciences. *Journal of Animal Science* 84:2316–2337.
- Zhu, M.J., S.P. Ford, P.W. Nathanielsz, and M. Du. 2004. Effect of Maternal Nutrient Restriction in Sheep on the Development of Fetal Skeletal Muscle. *Biology of Reproduction* 71:1968–1973.



By **Don Llewellyn**, Ph.D., Regional Extension Specialist, Benton County, Kennewick, WA; **Sarah Smith**, M.S., Extension Educator, WSU Grant County Extension, Ephrata, WA; and **Min Du**, Ph.D., Professor, Washington State University Department of Animal Science, Pullman, WA.

Copyright 2012 Washington State University

WSU Extension bulletins contain material written and produced for public distribution. Alternate formats of our educational materials are available upon request for persons with disabilities. Please contact Washington State University Extension for more information.

You may download copies of this and other publications from WSU Extension at <http://pubs.wsu.edu>.

Issued by Washington State University Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, and national or ethnic origin; physical, mental, or sensory disability; marital status or sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended. Published December 2012.

EM060E