Learning More About Fetal Programming

Researchers evaluate cow and calf performance when a protein restriction occurs during pregnancy.

*by **Kindra Gordon***

Fetal programming research, among both humans and animals, suggests that certain environmental factors that occur during embryonic and fetal development can reset physiological parameters of the fetus. This can influence physical attributes and health into adulthood, and possibly into the next generation of progeny.

For instance, scientists have long cautioned that smoking or alcohol consumption by pregnant females can adversely affect development of their unborn child. But, researchers are also learning that nutrition during pregnancy is also a critical environmental factor that can impact the future health and performance of a person or an animal.

As fetal programming knowledge and research is advancing, new studies are looking at manipulating, usually restricting, specific nutrients such as energy, protein or certain types of minerals. Additionally, scientists are evaluating the effects of timing of the dietary restriction during gestation.

A research question to consider: Does a nutritional restriction to a pregnant female create permanent changes to the unborn fetus that affect how that individual will perform throughout its entire life?

That was the focus of one recent collaborative study on cattle conducted with funding from the South Dakota Beef Industry Council, which involved South Dakota State (SDSU) animal science faculty members Amanda Blair, Ken Olson, Keith Underwood and Michael Gonda; University of Nebraska researcher Rick Funston; and SDSU animal science graduate students Janna Kincheloe and Megan Webb.

Protein restriction

The research question evaluated in the study was focused on the impact of a protein restriction in pregnant first-calf heifers' diets. Progeny from those heifers were then monitored through the beef production cycle and evaluated for feedlot and carcass performance.

A total of 108 females were in the research trial conducted at a SDSU research station near Philip, S.D. The bred heifers were divided into four groups with a protein restriction implemented in mid-gestation, late gestation, or throughout both mid- and late-gestation. There was also a control group that experienced no protein restriction throughout gestation.

The researchers explain that a protein restriction in mid- to late-gestation was chosen because it can be representative of a real ranch setting. SDSU's Ken Olson notes that with cows on dormant range or corn stalks prior to calving, protein may be limited in their diet during the second and third trimester.

The 108 females were bred in June 2013, and the three affected groups experienced their protein restriction during gestation and prior to calving in March 2014. That was the only time the females experienced any kind of dietary restriction. Heifers were weighed and body condition scores were evaluated at the beginning and the end of each gestational period, with ultrasounds conducted to evaluate heifer body composition at the same time points.

When calves were born in March and April, data were collected on birth weights, calf vigor and calving difficulty. Additionally, within 48 hours after birth, muscle biopsies were collected from 12 calves — three within each treatment group. This collection was done to evaluate gene expression using next generation sequencing (RNA-Seq).

Following calving, pairs were managed as a common group in a typical range-based production setting through weaning. All calves were weaned and preconditioned for two weeks in October 2014 before being shipped to North Platte, Neb., where the University of Nebraska-Lincoln West Central Research and Extension Center has a GrowSafe feeding system that allowed for collection of individual feeding data for each animal.

Calves were fed a typical finishing diet, and feed intake, average daily gain and feed efficiency were evaluated. Two weeks prior to harvest, muscle biopsies were again collected on the same 12 head that were sampled at birth. This collection allowed researchers to determine if changes in gene expression were maintained over time. All steer and heifer progeny were harvested in 2015 at the Tyson plant in Lexington, Neb., with carcass data collected including hot carcass weight and ribeye area, fat thickness and marbling scores. Yield grade and quality grade were calculated for each carcass.

To evaluate meat quality, a strip loin was collected from each carcass to determine Warner-Bratzler Shear Force (measure of tenderness) as well as the fatty acid profile. Rib sections were also collected from a subsample of carcasses to determine the impact of gestational treatments on carcass composition.

Based on a large body of previous research, researchers advise that producers should meet protein and other nutrient requirements of pregnant females in order to ensure optimal calf health and subsequent reproductive performance of cows.

The implication

Pregnant heifers that experienced a protein restriction at various periods throughout gestation lost weight and condition compared to heifers on the control diet. In addition, ultrasound measurements indicated that restricted heifers lost ribeye area, indicating that body stores were being mobilized in response to the protein restriction. However, despite impacts on heifer performance, the researchers found there were no differences in birth weight or weaning weight of progeny due to the dam's nutritional treatment. In addition, there were few differences in feedlot performance, carcass composition and meat quality characteristics among offspring.

However, the researchers did find differences in gene expression based on muscle biopsies collected at birth. SDSU's Amanda Blair explains in progeny that received a protein restriction during gestation, "Genes involved in muscle tissue development were down-regulated and genes involved in fat development were up-regulated or turned on."

Thus, the researchers say they might have expected smaller carcasses with reduced ribeye areas and more fat from those progeny. However, the differences identified in the genome were not consistent with carcass characteristics and meat quality.

While the exact mechanisms responsible for the responses observed in this trial are yet to be determined, it is possible these processes were further influenced by external factors such as environment or observed genetic differences may have resulted in phenotypic changes later in the animal's life, suggests Blair.

It also appears that metabolic and/or physiological mechanisms may have allowed the dam to absorb most of the impacts of the restriction herself through mobilizing body stores, thus protecting her unborn calf from the nutritional insult, suggests Olson. Additionally, when nutrition returned to normal following calving, cows did recover and no differences were detected in breed-back percentages.

With continued research, scientists hope to gain a better understanding of how cattle respond to various conditions experienced during gestation and how this impacts lifetime performance and production of livestock.

Producer perspective

For cattle producers, Olson and Blair underscore that the take away from this research is not that protein supplements are unnecessary. They point out that it is important to consider that this study was conducted over one production cycle using a group of cows from a common genetic background. Furthermore, Blair explains, "Responses may not be consistent if a different type of cattle were fed under alternate environmental conditions and study parameters."

The researchers say it is also noteworthy that diets for this study were formulated to meet energy requirements for all heifers, with protein being the only restricted nutrient. Energy deficiency may result in impacts on cow and calf performance that were not observed in this study, Olson says. Based on a large body of previous research, he also advises that producers should meet protein and other nutrient requirements of pregnant females in order to ensure optimal calf health and subsequent reproductive performance of cows.

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As one example, Blair shares a study conducted by another research group indicates that a restriction in mid-gestation may affect formation of reproductive organs of progeny and could have negative impacts on fertility. Although reproductive response of heifer offspring was not evaluated in this particular study because all heifer offspring were harvested to determine impacts on carcass characteristics, this is an issue of extreme importance to producers.

"Additional fetal programming research is needed to determine more about how nutrients flow from the dam to the fetus and how various developmental processes are affected based on maternal diet," she says. "Increasing our understanding of nutrient requirements at various stages of gestation will be important in guiding nutritional management strategy recommendations for livestock producers in the future." HW