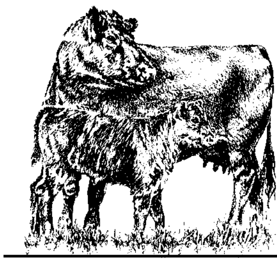

Effects of Management and Nutrition on Embryo and Fetal Development

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One of the main goals of cow-calf systems is to maximize pounds of calf weaned per cow exposed. Time of year at calving, weather, maternal milking ability, breed type, genetics, age of calf at weaning, herd health and vaccination programs, and post-weaning treatment of the calf are factors that may influence sale weight of the calf. The uterine environment and nutritional status of the dam have long been known to impact embryonic and fetal development. In recent years, however, we have also come to understand that the environment provided in utero may exert "carry-over effects" on the calf; that is, the effects of the uterine environment impact the growth and performance of the calf after birth and even after weaning.

Growth and development of the calf begins with fertilization of the egg within the dam's reproductive tract. Throughout the subsequent 282 days of gestation, this growth and development may be measured and observed through the use of ultrasound technology (Table 1) and, to some extent, via rectal palpation. While we are unable to visually observe the calf throughout pregnancy, it is important to note that proper management during key biological events may have a tremendous impact on calf development and performance after birth.

Pre-breeding and Early Gestation

The need for proper cow nutrition between the time of calving and the beginning of the breeding season has been well documented. Data from Houghton et al. (1990) demonstrated that thinner cows on an upward plane of nutrition from calving to breeding achieved greater pregnancy rates than fat cows losing condition during the same period. In general, however, cows should be at a body condition score (BCS) between 5 and 6 on a scale from 1 to 9 (for more information, see 331) by the start of the breeding season. This is particularly important for first-calf heifers and young cows.

Table 1. Day of first detection of ultrasonographically identifiable characteristics of the bovine conceptus.

	First day detected	
Characteristic	**Mean (days)**	**Range (days)**
Embryo proper	20.3	19 to 24
Heartbeat	20.9	19 to 24
Allantois	23.2	22 to 25
Spinal cord	29.1	26 to 33
Forelimb buds	29.1	28 to 31
Amnion	29.5	28 to 33
Eye orbit	30.2	29 to 33
Hindlimb buds	31.2	30 to 33
Placentomes	35.2	33 to 38
Split hooves	44.6	42 to 49
Fetal movement	44.8	42 to 50
Ribs	52.8	51 to 55

Adapted from Curran et al. 1986.

Once pregnancy has been achieved, the rate of fetal growth depends primarily on nutrient supply and the ability of the fetus to utilize those nutrients. During early gestation, placental growth and fetal organ development occurs (Funston et al. 2009), and nutritional insults during this period may negatively impact the calf. Additional nutrient requirements due to fetal development during this phase are minimal, but it is important to keep cows in a positive energy balance (by either maintaining or gaining weight) after artificial insemination (A.I.) or bull turnout. For cows with calves at their sides, however, early gestation coincides with peak lactation, which in turn significantly increases nutrient requirements (for more information, see Tables 2 and 3 and 330).

As mentioned previously, placental growth occurs during this period. Proper placental growth and development are critical for the survival and normal development of the fetus, as the placenta provides an interface with the dam (fetal placenta:maternal uterus) for nutrient and waste exchange (Funston et al. 2009). Vascularization (development of capillaries and other blood vessels) of the placenta is particularly important for these exchanges. Cows that are nutrient restricted before achieving pregnancy have been shown to have decreased vascularization at the placental-uterine interface; however, some of this can be compensated if cows are subsequently put on a higher plane of nutrition during pregnancy (Funston et al. 2009).

Various organs develop at differing times throughout early gestation. As shown in Table 1, the heart is the first organ that can be viewed ultrasonographically, and this is possible by day 21 of pregnancy. Limbs and other organs may begin to be viewed around day 30. The bull calf's testicles and heifer calf's ovaries, on the other hand, cannot be seen until days 45 and 50-60, respectively (Funston et al. 2009). If the nutrition of the dam is compromised at any of these stages, organs developing at that time may be compromised.

Muscle development within the fetus is especially susceptible to the effects of suboptimal dam nutrition, because muscle fibers receive lower priority in nutrient partitioning than other tissues (Funston et al. 2009). Data have shown that steers from cows that were nutrient-restricted during this time of gestation weighed less and had lighter carcasses at 30 months of age compared with steers from cows who were not nutrient-restricted (Greenwood et al. 2004).

As mentioned previously, there are key biological events during pregnancy that may affect the success of the pregnancy. One of these critical windows of metabolic activity is between maternal recognition of pregnancy (14 to 17 days after fertilization; Senger 2003) and implantation and differentiation of the embryo (around 42 days after fertilization; Senger 2003). Dramatic changes in diet and transporting cattle long distances during this period may result in early embryonic loss. For those producers who artificially inseminate their cows, the general recommendation is that cows should be moved or transported within eight days after A.I. (excluding the first 24 hours post-A.I.) or 40 days after insemination.

Mid-Gestation

During the second trimester the fetus continues to grow, but it will only reach about 25 percent of the size it will be at birth; therefore, the nutritional requirements of the beef cow do not increase substantially above maintenance requirements during this period. However, weaning typically occurs when cows are in mid-gestation, therefore they often lose a little condition during this period given that dry cows are commonly left to fend for themselves.

Nevertheless, it is important to recognize that although fetal growth is fairly minimal at this stage, it is during this time that the majority of organ development occurs, which can have lifetime implications on production (Long et al. 2009). Therefore, although the nutritional requirements of beef cows do not increase dramatically from the first to second trimester, it is essential to meet these requirements; if not, future performance of offspring may be impacted for years to come. It is important for producers to remember that the future replacements of the beef herd are being fed in utero during this time.

Late Gestation and Parturition

The majority of fetal development has already occurred by the beginning of the final trimester. However, 75 percent of fetal growth occurs during this phase, which in turn means that the cows' energy and crude protein requirements increase by 25 percent (Tables 2 and 3) compared with mid-gestation. For this reason it is extremely important to have nutrient analyses performed on hay and feed samples; once this has been done, rations should be balanced to meet both energy and protein requirements of the pregnant cow.

While fetal development is nearly complete by this stage, protein supplementation during the last trimester has been shown to exert reproductive benefits on heifer calves born to supplemented cows. Funston et al. (2009) reported that a greater number of heifers from protein supplemented cows reached puberty before the breeding season compared with heifers from non-supplemented cows. In addition, heifers from supplemented cows

Table 2. Change in net energy requirements (Mcal/d) for maintenance of a 1,200-pound beef cow from mid-gestation through early lactation (NRC 2000)**.**

Time	Mcal/day
Mid-gestation	8.86
Late-gestation	10.83
Early lactation (10 lb milk)	12.09
Early lactation (20 lb milk)	15.48

Table 3. Change in crude protein (lb/d) for maintenance of a 1,200-pound beef cow from mid-gestation through early lactation (NRC 2000)**.**

Time	Mcal/day
Mid-gestation	1.4
Late-gestation	1.7
Early lactation (10 lb milk)	2.1
Early lactation (20 lb milk)	2.7

had greater pregnancy rates than heifers from non-supplemented cows (Martin et al. 2007). This study also suggested that despite the difference in reproductive success of these heifer calves, there was no difference in birth weight of calves born to supplemented or non-supplemented cows.

The relationship between BCS at parturition and the amount of time required to resume estrous cyclicity postpartum has been well documented (Hess et al. 2005). Therefore, it is not only critical to meet the requirements of the cow and of the growing fetus, but it is equally important that cows are in the proper condition at calving to enable them to reduce dystocia, to provide high-quality colostrum and milk, and to rebreed in a timely manner.

Post-Natal Management

The intra-uterine environment during gestation may affect calf performance after birth, as stated previously. Calves born to thin first-calf heifers and calves born to cows that were only fed at 70 percent of their nutrient requirements during the last trimester had increased morbidity rates (Funston et al. 2009). This can lead not only to an increase in mortality, but also to a decrease in overall calf performance. Morbidity in newborn calves, including respiratory problems and diarrhea, has been reported to decrease their weaning weights (Funston et al. 2009).

Differing energy contents in the diet for the last trimester have been shown to effect subsequent calf performance. Calves from cows on a high-energy diet had lesser morbidity and greater weaning weights than calves from cows on a low-energy diet (Funston et al. 2009). In addition, cows receiving a high-energy diet had greater body weights and BCS than cows on a low-energy diet.

As stated earlier, heifer calves from protein-supplemented dams had greater reproductive success later in life. However, these heifers also were less efficient and had greater dry matter intakes (DMI) than heifers from non-supplemented dams. Steers born to the same supplemented cows had greater weaning weights, average daily gains, carcass weights, and percentage body fat, but these steers also consumed more feed (Larson et al. 2009).

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Fourth edition; December 2016 Reprint