Factors Influencing Calf Livability

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Introduction

While failure to get beef females pregnant is the major cause of reproductive loss in beef herds, calf death loss at birth or between birth and weaning is also a significant source of reduced reproductive rate. Furthermore, the economic impact of this loss is especially significant since considerable expense has been incurred in getting the beef female to calving. In a summary of three research studies by Bellows and Short (1994), the average percentage of calves born dead was 7.0% of those calving while subsequent losses to weaning averaged another 6.7% of those born alive. A survey of Kansas ranches published by Simms et al. (1986) indicated that 5.8% of calves born didn't survive until weaning. A summary of over 4,000 calvings over a 21 year period in Colorado (Holland et al., 1992) showed a loss of 4.7% of the calves in the first 21 days of life and another 3.4 % loss from 21 days to weaning. Thus, numerous studies have shown that calf death loss is a significant factor in net reproductive rate; and since reproductive rate is the most important production factor influencing profitability, calf death loss has a very significant impact on overall profitability in the beef cattle industry.

Causes of Calf Death Loss

There have been several summaries published indicating the major causes of calf death loss. The largest summary (Patterson et al., 1987) of 13,296 calvings at the Fort Keogh Range Livestock Research Station at Miles City, MT, indicated that 6.7% of the calves died between birth and weaning. The major cause of death was dystocia, which caused approximately 51% of these deaths (Bellows et al., 1987). The second leading cause of death (12.8%) was disease (pneumonia and scours).

In a summary by Holland et al. (1992) from Colorado, 50.3% of the neonatal deaths (before 21 days of age) were stillborn with a high percentage of these associated with dystocia. Scours accounted for 12.6% of the neonatal deaths while hypothermia accounted for another 5.2%.

In a report from Florida by Koger et al. (1967), summarizing 3408 calvings over a five year period, the most important variable influencing calf death loss was breed. Only 85.8% of the Brahman calves survived to weaning compared to 90.2% of the crossbred calves sired by Brahman bulls and to 92.5 to 96.2% for other breed groups. Aged cows (11 years old or older) also had reduced survival rates of their calves. Calf birth weight had a highly significant quadratic effect with both low and high birth weights reducing survivability.

In summary, all of the factors that cause dystocia contribute to lower survival rates. Additionally, factors, which reduce the calf's ability to fight disease and handle environmental stress, are key causes of reduced calf survival. Clearly, then, management practices, which reduce calving problems and increase calf vigor and immune response, have the potential to reduce calf death loss.

Factors Influencing Calf Survival Rates

Breed Effects on Survival

Koch et al. (1994) summarized the germ plasm evaluation research at the U.S. Meat Animal Research Center with respect to breed effects on survival rates. As a general statement, the differences in survival rate when breeds were used as sires tended to be a reflection of relative differences in birth weights and dystocia. In other words, for the most part, the breeds that caused the heaviest birth weights caused the most calving difficulty, which reduced survival rates.
As part of this evaluation project, they also studied F_1 cows developed by crossing all of the major breeds to Angus or Hereford cows. Averaged over the first six calf crops, survival rates of calves were similar for all breeds.

As noted previously, research in Florida (Koger et al., 1967) indicated that the survival rate of Brahman calves was lower than that of Brahman crosses which was lower than the *Bos taurus* breeds in the study. The reasons for these differences weren't noted. In a genotype X environment study reported by Olson et al. (1991), where *Bos taurus* and *Bos indicus* crosses representing the same germ plasm were raised in Florida and Nebraska, survival rates were similar for all breed types in each environment. This result is somewhat surprising given that the *Bos indicus* crosses exhibited much lower levels of dystocia than the *Bos taurus* crosses. These research studies indicate that in *Bos indicus* cattle, factors other than dystocia have a greater impact on survival than is the case with *Bos taurus* cattle.

Adaptation of cattle to the environment can also be a factor in survival rates. In a study in Nebraska, Josey et al. (1987) evaluated calf death loss in calves containing 0, 25, 50, or 75% *Bos indicus* breeding. Death loss was higher when the percentage of *Bos indicus* exceeded 25% combined with cold stress in the form of cold temperatures, cold and wet conditions, or cold and windy conditions.

Effects of Heterosis

The very term heterosis or hybrid vigor implies that crossbred calves should have higher survival rates. Additionally, one might expect crossbred dams to have a positive impact on calf survival. In a summary of several research trials prepared by Koch et al. (1994), the average heterosis for calf survival for *Bos taurus* cross calves was 1.1%. The average heterosis for *Bos taurus* cross dams for calf survival was also 1.1%. The corresponding percentages for *Bos indicus* crosses were 1.9 and 2.6%, respectively.

It is somewhat surprising that the levels of heterosis for calf survival weren't higher in these studies. However, it should be noted that there is considerable heterosis for birth weight, which means that crossbred calves tend to be larger resulting in more calving problems. Consequently, some of the increased survival expected from a more vigorous calf is lost as a result of added calving difficulty. Also, a review of the research summarized by Koch et al. (1994) suggests that the level of heterosis was higher in the studies conducted in northern climates where environmental stress offers greater challenges to survival.

Effect of Calving Difficulty

As noted previously, dystocia is the number one cause of calf death loss.. Obviously, most of this death loss results from the tremendous stress on the calf during a difficult birth. However, research has shown that calving difficulty may also have long term effects on immune status of the calf. In a Colorado study (Odde et al., 1986), two-year-old heifers were scored for calving problems using a system where 1 = no assistance, 2 = easy pull, and 3 = hard pull. Table 1 shows the impact of dystocia on mothering score and the concentration of immunoglobulins in the colostrum in this study.

Table 1. Effect of Calving Difficulty on Immunoglobulin Concentration, Interval from Calving to Standing, and Mothering Score

	Calving Difficulty Score			
	1	2	3	Sign. Level
Interval from Calving to Standing, min.	39.8	50.9	84.3	.01
Mothering Score	1.2	1.5	1.5	.02
IgG_1 (mg/dl)	2401	2191	1918	.01
IgM (mg/dl)	195	173	136	.05

Modified from Odde et al. (1986)

This research shows that calving difficulty has the potential to reduce the passive immunity of the calf, which could make it more susceptible to disease. In addition, calf vigor and mothering score were reduced by dystocia.

Effect of Body Condition Score

Body condition score has been shown to be a good general indicator of previous plane of nutrition and a fairly good predictor of reproductive performance. Odde et al. (1986) studied the effect of body condition at calving on calf vigor, colostrum production, and immunoglobulin levels in the colostrum as shown in Table 2.

Table 2. Effect of Condition Score at Calving on Interval from Calving to Standing, Colostrum Production and Immunoglobulin Concentration

	Condition Score			
	3	4	5	Sign. Level
Interval from Calving to Standing, min.	60	64	43	.24
Colostrum Production, ml	1525	1112	1411	.19
IgG_1 (mg/dl)	1998	2179	2310	.23
IgM (mg/dl)	146	157	193	.05

Modified from Odde et el. (1986)

As shown, there was a general trend for calf vigor, colostrum production and immunoglobulin concentration to increase as body condition increased, although in most cases the differences weren't statistically significant.

Effect of Energy Intake Prior to Calving

Clearly, there is a relationship between energy level in the diet and body condition at calving. However, there have been numerous studies evaluating the effect of prepartum nutrition on calf survival. For axample, in two experiments, Corah, et al. (1975) fed the control group the amount of energy recommended by NRC. The restricted group received 50% or 65% of the recommended amount of energy prior to calving. These diets were formulated to be isonitrogenous. Calf birth weights were reduced in the restricted group, but the level of dystocia and the severity were similar for both treatments. The most significant result was that 100% of the calves in the adequate group were born alive compared to only 90% in the restricted treatment. Furthermore, 100% of the calves in the adequate group survived to weaning compared to only 71% in the restricted group. The major cause of death was scours, which killed 19% of the calves.

Effect of Protein Intake Prior to Calving

There have been several studies evaluating the impact of protein intake precalving on subsequent immunoglobulin levels in the colostrum and the calf's ability to absorb these immunoglobulins. For example, Blecha et al., (1981) fed cows crude protein levels ranging from .52 to .98 kg per day for the last 100 days before calving. Prenatal protein intake didn't influence immunoglobulin (IgG_1, IgG_2, IgM) levels in the sera of the cow or in the colostrum. However, serum concentration of IgG immunoglobulins was significantly lower in calves in the low protein group. The concentration of IgM immunoglobulins wasn't influenced by the dam's protein intake precalving. Thus, it appears from this study that low protein levels fed prepartum may impact the calf's ability to absorb some immunoglobulins.

In a similar study Holland et al. (1987) fed either adequate (1.36 lbs/d) or inadequate (.84 lbs/d) protein to first-calf-heifers during the last 90 days before calving. Results from this study are shown in Table 3.

Table 3. Effect of Adequate or Inadequate Protein Levels Precalving on Calf Performance, Colostrum Parameters, and the Calf's Ability to Absorb Immunoglobulins.

Item	Adequate	Inadequate	Sign. Level
Gestation Length, days	281	283	.16
Birth Weight, lbs.	74.8	74.4	.89
Interval from Calving to Standing, min.	66.0	97.4	.12
Colostrum Volume, ml	2683	1931	.15
Protein, %	14.0	15.1	.01
Total Protein, g	369.3	292.3	.28
IgG1 First liter concentration, mg/dl	5810	7157	.05
IgG1 Total production, g	138	134	.89
IgM First Liter Concentration, mg/dl	511	639	.11
IgM Total Production, g	11.65	11.51	.95
Calf Serum IgG1 at 3 hr, mg/dl	248.7	190.4	.54
Calf Serum IgG1 at 12 hr, mg/dl	1059	1467	.03
Calf Serum IgG1 at 24 hr, mg/dl	1112	1684	.01
Calf Serum IgM at 3 hr, mg/dl	31.5	30.9	.93
Calf Serum IgM at 12 hr, mg/dl	125	175	.01
Calf Serum IgM at 24 hr, mg/dl	113	181	.07

In summary, inadequate protein reduced calf vigor and colostrum production. However, cows which had received inadequate protein produced colostrum higher in concentration of immunoglobulins. When interpreting the calf serum levels in Table 3, it is important to note that the calves were all fed 1 liter of their dam's colostrum. And since the colostrum from the inadequate dam's contained a higher concentration of immunoglobulin, this protocol resulted in higher sera levels in the calves in the inadequate protein treatment. However, it does appear that absorption of immunoglobulins wasn't reduced in the calves from the dam's on the inadequate protein treatment as was observed in the study by Blecha, et al. (1981). Consequently, there is some confusion regarding the effect of inadequate protein prior to calving on absorption of immunoglobulins by calves, but there is agreement that colostrum quantity is reduced by inadequate protein, which impacts calf growth. Also, as noted, calf vigor is reduced by inadequate protein prior to calving.

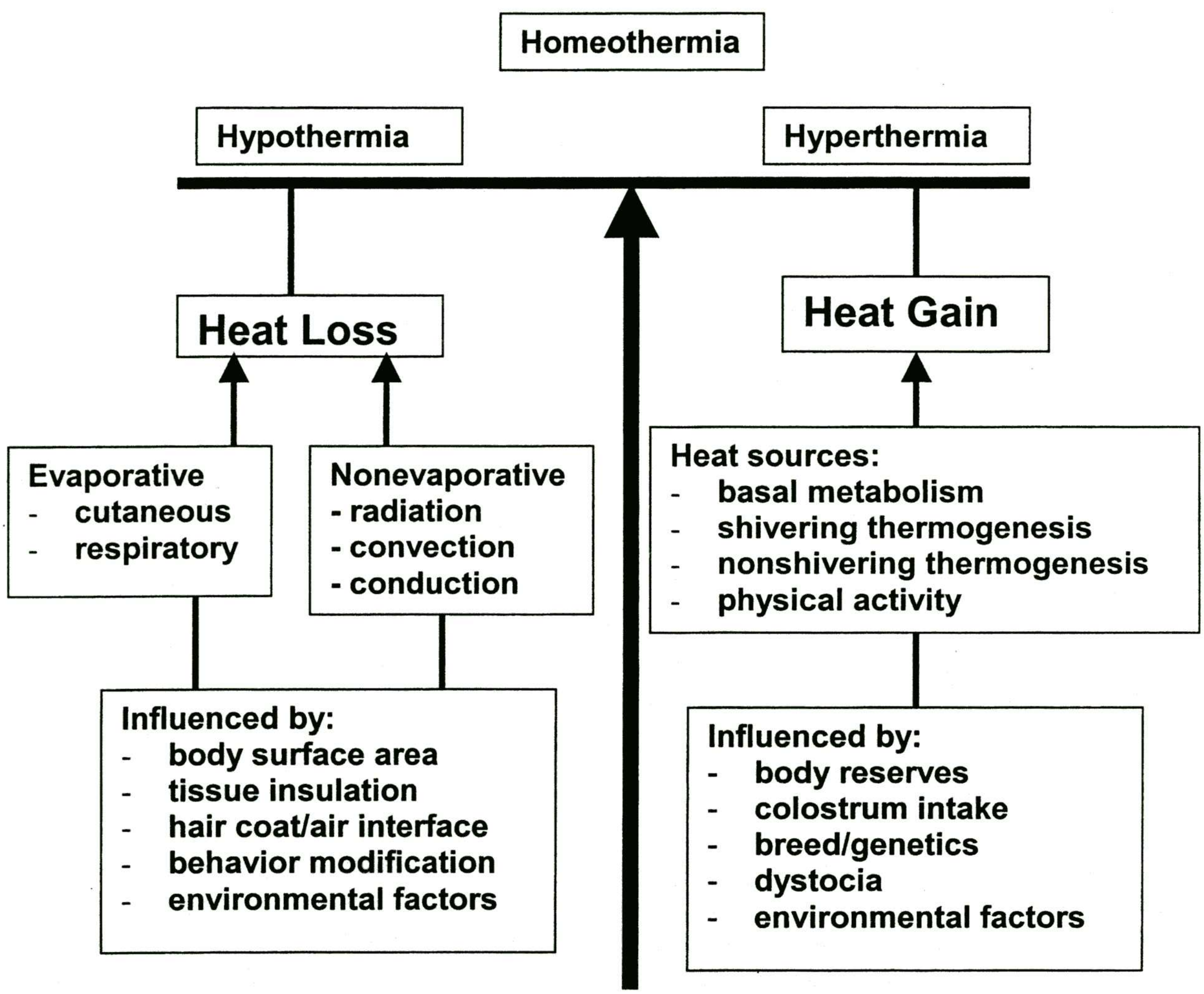
Effect of Birth Weight

While the major impact of birth weight on calf survival is a result of its relationship to calving difficulty, birth weight does impact calf survival in other ways. Specifically, calf survival has been shown to be reduced even when dystocia is minimal. Koger et al. (1967) noted this reduction in survival with birth weights well below average, as did Koch et al. (1994). It appears that calves with small body mass have less ability to handle environmental stress and disease challenges.

Effect of Feeding Diets High in Lipid

Lammoglia et al. (1999) working at the Fort Keogh Range Livestock Station, Miles City, Montana, studied the effect of prepartum diets high in lipid on reproduction and calf response to cold stress. Interpreting their results requires some discussion of thermogenesis in the neonate. The ability of the neonate to maintain normal core body temperature is a function of its ability to produce enough heat to balance the loss of heat from evaporative and nonevaporative heat losses. This relationship is shown in Figure 1.

Figure 1. Thermal balance between heat loss and heat gain in neonatal ruminants. (Modified from Carstens, 1994)



Production of heat to maintain homeothermy in the neonate depends on shivering thermogenesis in the muscle and nonshivering thermogenesis in brown adipose tissue (BAT). BAT is a specialized type of tissue with the ability to release heat, especially in response to cold stress. It has been estimated that 40% of the thermogenic response during summit metabolism can be attributed to nonshivering thermogenesis with the balance attributable to shivering thermogenesis.

Thus, there are two types of adipose tissue in the neonatal ruminant, white and BAT. The primary function of white adipose tissue is storage and release of fatty acids for use as an energy source. The primary function of BAT is the generation of heat through nonshivering thermogenesis. It is located in the perirenal adipose tissue depot and is highly innervated by the sympathetic nervous system. The release of norepinephrine during cold stress stimulates increased blood flow and thermogenesis in BAT.

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Lammoglia et al. (1999) conducted two studies to determine if feeding high fat diets during gestation would increase the calf's ability to handle cold stress. In the first study, dams were fed isocaloric-isonitrogenous diets containing either 1.7% fat (controls) or 4.9% fat during the last 50 days of gestation. The source of the fat was safflower seed which contained approximately 37% fat with 80% from linoleic acid. At four hours of age, the calves were placed in a controlled temperature room at 0 degrees C for 140 minutes. Treatments in study two were similar except the fat level in the high fat treatments was 3.4% and the nutritional treatments were imposed for 45 days precalving.

Rectal temperatures during the first 50 minutes of the cold challenge were higher for the calves in the low fat group, but after about 40 minutes, they declined rapidly. Conversely, temperatures during the first 50 minutes in the high fat group were lower, but the calves were able to maintain a higher rectal temperature than the low fat calves during the final 50 minutes of the cold stress challenge period. Plasma glucose levels during the cold stress challenge were significantly higher for the calves from the high fat treatment. The authors concluded that calves from dams fed high fat diets during late gestation exhibited superior nonshivering thermogenesis. They also concluded that calves from dams fed high fat diets during late gestation could have improved ability to handle cold stress.

This research also showed that high fat diets during late gestation had a significant impact on birth weight and reproductive performance as shown in Table 4.

Table 4. Effect of high fat diets during late gestation on calf vigor, birth weight, dystocia, and pregnancy rate.

Trait	Control (1.7% Fat)	High Fat (4.9% Fat)
No.	35	35
Avg. Birth Wt., kg	36.1	37.8**
Dystocia Score	1.7	1.8
Calf Vigor Score	1.1	1.3
Pregnancy Rate	57	77[a]

[a]P = .06
** P < .01

The improvement in pregnancy rate was particularly impressive given that the diets were isocaloric and isonitrogenous. These workers have concluded four years of research evaluating high fat diets during late gestation on performance and reproductive performance of two-year-old heifers. In general, they have fed these high fat diets for the last 50-60 days prior to calving, and they have used various oilseeds as the source of fat. Pregnancy rates were increased by over 10% on average and weaning weights were increased by 30 lbs in the two years that weaning weight data were collected. While the results have been variable, it appears that feeding high fat diets increased birth weights by approximately 3 lbs. In their production system, this slight increase in birth weights increased dystocia to some extent.

Research at numerous universities and experiment stations has shown that feeding diets high in fat during either late gestation or between calving and breeding can positively impact reproductive performance. The work at the Fort Keogh Range Livestock Experiment Station indicates that these diets fed during late gestation may also improve the calf's ability to survive cold stress. The results of research conducted to date indicates that the effect of high fat diets on both reproductive parameters and calf survivability should be areas of major research focus.

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