Understanding the Effects of Stress on Embryonic Mortality in Cattle

By Sarah Fields* and Dr. George Perry‡
**Graduate Research Assistant in Beef Reproduction*
‡Beef Reproduction & Management Specialist SDSU Animal & Range Sciences

The number of cows bred during the breeding season plays the largest role in percent calf crop weaned, and percent calf crop weaned is one of the most important factors influencing profitability in beef operations. Furthermore, embryonic loss is the greatest economic loss in the cow/calf industry. Therefore, management decisions should take into account factors that may influence embryonic mortality.

Fertilization rates are usually between 90% and 100% when semen is present at the time ovulation occurs. While fertilization usually takes place, conception rates (number of animals that conceive divided by number of animals inseminated) are usually around 70% for natural service or artificial insemination. Although nature (poor oocyte quality, disease, chromosomal abnormalities, etc.) contributes much of this loss, management practices can also increase embryonic mortality. Stress, particularly heat and shipping stress, can be detrimental to embryos and decrease pregnancy rates.

Embryonic Development
In order to understand how stress may increase embryonic mortality, one must first understand the development of the embryo *(Table 1)*. Just like the estrous cycle, embryo development begins on day 0, or the day of standing estrus. This is the day the female is receptive to the male and insemination occurs. Ovulation occurs on day 1 or about 30 hours after the first standing mount *(day 0 Wiltbank et al., 2000)*. If viable sperm is present, fertilization occurs inside the oviduct shortly after ovulation. The first cell division occurs on day 2, and by day 3 the embryo has reached the 8-cell stage *(Shea, 1981)*. Between days 5 and 6 the embryo migrates into the uterine horn and by day 7 to 8 it forms into a blastocyst *(Shea, 1981; Flechon and Renard, 1978; Peters, 1996)*. At this stage two distinct parts of the embryo can be seen: 1) the inner cell mass, which will form into the fetus and 2) the trophoblast, which will form into the placenta. Between days 9 and 11 the embryo hatches from the zona pellucida, a protective shell that has surrounded the embryo to this point *(Shea, 1981; Peters, 1996)*. Then, on days 15 to 17, the embryo sends a signal to the cow to tell her she is pregnant *(Peters, 1996)*. This is the first signal that the cow gets to know if she is pregnant. The embryo attaches to the uterus beginning on day 19, and around day 25, placentation, an intricate cellular interface between the cow and the calf, begins. By

day 42 the embryo has fully attached to the uterus of the cow *(Peters, 1996)*.

Table 1. Time course of early bovine embryo development

Event	Day
Estrus	0
Ovulation	1
Fertilization	1
First cell division	2
8-cell stage	3
Migration to uterus	5-6
Blastocyst	7-8
Hatching	9-11
Maternal recognition of pregnancy	15-17
Attachment to the uterus	19
Adhesion to uterus	21-22
Placentation	25
Definitive attachment of the embryo to the uterus	42
Birth	285

Shipping Stress and Embryonic Mortality

With the knowledge of the critical time points in embryonic development, it is possible to completely understand how stress from shipping can result in increased embryonic mortality in cows *(Table 2)*. When animals are loaded on a trailer and hauled to a new location, they become stressed and release hormones related to stress. These hormones lead to a release of different hormones that change the uterine environment in which the embryo is developing. During blastocyst formation, hatching, maternal recognition of pregnancy, and attachment to the uterus, the embryo is vulnerable to these changes. These most critical time points are between days 5 and 42 after insemination. Before day 5, the embryo is in the oviduct and is not subject to changes in the uterine environment. Therefore, stress does not influence embryo survivability at this time. The greater the length of time after day 42, the less severe the influence of shipping stress on embryonic loss appears to be. At the time of complete attachment of the embryo to the uterus the embryo is supported by the mother and appears to be not as easily affected by changes in its environment. On the other hand, in between these time points (5 - 42 days), the embryo is at greatest risk. Shipping during this time can cause detrimental changes to the uterine environment and may result in embryonic mortality.

Table 2. Effect of time of transport after insemination on pregnancy rates

	Days after insemination that transportation occurred			
	1 to 4	8 to 12	29 to 33	45 to 60*
Synchronized pregnancy rate	74%	62%	65%	
% pregnancy loss compared to transportation on days 1 to 4		12%	9%	6%*
Breeding season pregnancy rate	95%	94%	94%	
*Loss compared to percent pregnant prior to transportation *(pregnancy determined by transrectal ultrasonography)*				
Data adapted from Harrington et al., 1995, and Merrill et al., 2007				

When should I not ship cows?

Shipping cows between days 5 and 42 can be detrimental to embryo survival and cause around a 10% decrease in pregnancy rates *(Table 2)*. Research has also demonstrated that shipping cattle 45 to 60 days after insemination can result in 6% of embryos being lost. Therefore, even shipping cattle 45 to 60 days after insemination may increase embryonic mortality. Critical time points such as blastocyst formation, hatching, maternal recognition of pregnancy, and adhesion to the uterus take place during this early time of pregnancy. If any of these time points are disturbed, then the result would lead to increased embryonic mortality and decreased pregnancy rates. Therefore, it is important to plan on transporting cattle before the breeding season or immediately after insemination.

When can I ship cows?

Shipping between days 1 - 4 is best. The embryo is still in the oviduct during this time; therefore, it is likely not subjected to uterine changes. Also after day 45, the embryo is well established and fully attached with the placenta; therefore it is less susceptible to the changes resulting from stress. Shipping at this point is less risky. However, embryonic loss from shipping has been reported up to 60 days after insemination. Care should always be taken to try to reduce the stress involved when animals are shipped. Do not overcrowd trailers and handle cattle as gently and calmly as possible.

Table 3. Time Points for Shipping Pregnant Cattle

	Day
When to ship	1 – 4 or after 45 - 60
When not to ship	6 - 42

Heat Stress and Embryonic Mortality

The best time to ship cattle is during early stages of development. However, this is also the time point when the embryo is most susceptible to increased temperatures. Temperature, humidity, radiant heat and wind all affect heat stress in cows. The rectal temperature of cattle is normally 102.2^{o}F, and an increase in rectal temperature by as little as 2^{o}F can result in decreased embryonic development *(Ulberg and Berfening, 1967)*. When rectal temperatures reach 105.8^{o}F for as little as 9 hours on the day of insemination, embryonic development can be compromised *(Rivera and Hansen, 2001)*. Heat stress has also been reported to change follicular waves, resulting in reduced oocyte quality *(Wolfenson et al., 1995)*. Researchers have reported that heat stress 42 days prior *(Al-Katanani et al., 2001)* and up to 40 days after breeding can affect pregnancy rates *(Cartmill et al., 2001)*. This illustrates how important it is to plan ahead for the breeding season**.**

Several methods have been researched to reduce the effects of heat stress. Shade, fans and misters can all reduce the effects of heat stress in natural service or artificial insemination (A.I.) programs. These methods allow animals to stay cooler during the hottest parts of the day. In humid areas, misters may not actually benefit the animals. If the water cannot evaporate, it will not be effective at cooling the animal.

Producers that utilize A.I. can also implement timed A.I. (T.A.I.) protocols to increase pregnancy rates during the hot summer months. Timed A.I. has increased pregnancy rates over animals inseminated 12 hours after estrus detection in conditions of heat stress *(Aréchiga et al., 1998; de la Sota et al., 1998)*. This is most likely due to fewer animals showing signs of estrus when under heat stress. When the weather is too hot, animals tend not to move around as much and do not show signs of standing estrus. Heat detection is a vital part of getting more animals pregnant. Since fewer animals are seen in heat, fewer animals can be inseminated. In this case, T.A.I. would be the best protocol to use, because it eliminates heat detection.

Using embryo transfer during times of heat stress can also increase pregnancy rates. High quality, fresh embryos have been proven to increase pregnancy rates over A.I. in heat stressed cows *(Putney et al., 1989)*. Embryos at time of embryo transfer can adapt to the elevated temperatures. Therefore, use of embryo transfer during times of heat stress can improves pregnancy success.

Conclusion

Getting cows/heifers pregnant during the breeding season, especially early in the breeding season, can have a tremendous impact on the profitability of a cow/calf operation. Tremendous amounts of time, effort and costs are required to have a successful breeding season (natural service or A.I.). Stressing animals during critical time points of embryo development can have a tremendous negative impact on pregnancy rates. Heat stress can decrease pregnancy rates during early embryonic development, and stress from shipping can decrease pregnancy rates throughout early embryo development. Therefore, planning around the breeding season becomes an important management tool for maximizing pregnancy success.

References available upon request. They were omitted due to space