

# TWINNING IN BEEF CATTLE: AN OPPORTUNITY TO IMPROVE REPRODUCTIVE AND ECONOMIC EFFICIENCY OF BEEF PRODUCTION?

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## Introduction

The possibility of improving the rate of reproduction in beef cattle by selection for an increased rate of twinning has been debated with both pessimism and optimism since the early days of animal breeding. The success of selection for multiple births in sheep lifted hopes that a similar program for cattle would also be successful. Pearl (1912) wrote, "From the standpoint of practical breeder it is slightly important that the phenomenon of multiple gestation in normally uniparous animals be carefully studied. Any definite and heritable increase in the fecundity and fertility of the domestic animals, if it can be gained without loss of other desirable qualities, is greatly to be desired. Cases of multiple gestation are the 'favorable variations', which must serve as the foundations for the creation of more fertile breeds and races."

Pearl (1912) cited three cases of extraordinary fecundity in cattle. One cow of "the black polled breed" produced a total of 25 calves in eight calvings between 1842 and 1848, another cow calved four times and produced three sets of twins and one set of triplets between 1876 and 1878, whereas another cow produced 14 calves between 1902 and 1910. Other examples of exceptional fecundity in cattle have also been documented (Wentworth, 1912; Hayden, 1922).

Beef producers, however, are commonly opposed to twin births because of the number of problems associated with the trait. These include greater incidence of calf mortality, dystocia, stillbirths, abortions, calf abandonment, and retained placenta as well as longer rebreeding intervals and occurrence of freemartin heifers. Cady and Van Vleck (1978) pointed out that the question that should be answered before attempting to increase twinning in cattle, whether through genetic selection or the administration of hormones, is whether the advantages can profitably overcome the problems associated with the trait.

Another concern was whether selection experiments for twinning would be successful in markedly altering the twinning rate in cattle because of low heritability, low repeatability and small amount of variation associated with reproductive traits and long generation intervals needed for progeny testing for a trait with low heritability. The time and money costs of increasing twinning rate would make attainment of a profitable high-incidence twinning herd a difficult undertaking (Cady and Van Vleck, 1978).

If selection experiments for multiple births in cattle were successful, what use could be made of such animals? Obviously, a beef cow can wean more total calf weight by raising twins. Reproductive performance is known to be a major determinant of profitability for beef cattle producers. Melton (1995) reported that reproductive traits are twice as important economically as production traits for commercial cow-calf producers. Gregory et al. (1997) indicated that more than 50% of the feed units used by beef cattle in the United States are needed to meet maintenance requirements of reproducing females, considerably higher than the 3% needed in meat chickens (Gregory and Dickerson, 1989). Results from experimentation (twins produced by embryo transfer) and simulation of production systems have suggested the potential of a 24% increase in efficiency of producing beef by twinning (Guerra-Martinez et al., 1990).

Because selection for twinning would appear to be difficult and time consuming, the development of a population with a high twinning frequency ( $\geq 40\%$ ) that is competitive in both reproductive and economic efficiency would likely be required for consideration of a twinning technology by the beef cattle industry (Gregory et al., 1997). Results from the Twinning Project at the US Meat Animal Research Center (USMARC), Clay Center, Nebraska suggest that it could be feasible to increase twinning rate in cattle to an economically viable level (Echternkamp et al., 1990; Van Vleck and Gregory, 1996; Gregory et al., 1996; Echternkamp and Gregory, 2002). In that experimental herd, the frequency of fraternal twin births has increased from 3.1% per year to an annual rate of 50 to 55% in about 20 years (Echternkamp and Gregory, 2002). Gregory et al. (1996) stated that "If twinning technology is to be implemented it will require the use of cattle from this population (USMARC Twinning herd) because they are the only known source of germplasm available with high breeding value for twinning".

The primary objective of this paper is to review reports on twinning in cattle and discuss some of the biological and management factors relevant to a twinning technology in cattle. The paper will also discuss the implications of a twinning technology to the genetic improvement of beef cattle although with the limitation that a thorough economic assessment of twinning technology in beef cattle is not yet available.

## **Review of Literature**

### **The biology and diagnosis of twin pregnancy**

Twins are classified as fraternal or identical twins, based on their origin, the most common being fraternal or dizygotic twins. Since fraternal twins originate from two separate ova or eggs, multiple ovulations from the same ovary or one from each ovary must therefore precede dizygotic twinning. Identical or monozygotic twins result from dividing or splitting of an embryo during early development (i.e., within 8 to 10-d after conception). Generally, about 10% of the twin births in national cattle populations are identical twins (Echternkamp and Gregory, 2002).

Kirkpatrick (2002) reported that one of the most important changes in management that should accompany efforts to exploit twinning is determination of pregnancy status with regard to single vs twin pregnancies. Cows gestating twins need to be provided with a higher plane of nutrition and increased obstetrical care before and after calving. Ovulation rate can be measured by counting the number of corpus luteum (CL) observable on the surface of the ovaries several days after ovulation. Methods for diagnosing pregnancy status include transrectal palpation of the reproductive tract or transrectal ultrasonography to visualize the reproductive tract. Although ultrasonography seems to be the most reliable method available, constraints to the application of this technology for many producers is the availability of the equipment at a justifiable cost (Kirkpatrick, 2002). Alternative approaches for determining pregnancy status include evaluation of hormone or protein levels associated with luteal, fetal or placental tissues (Dobson et al., 1993; Takahashi et al., 1997; Patel et al., 1998; Chauvin et al., 1999).

### **Breed differences in twinning rate**

In typical beef herds, most twin births are unanticipated events occurring naturally at low frequencies (Kirkpatrick, 2002). Reviews of the genetics of twinning (Rutledge, 1975; Morris and Day, 1986) suggest that the twinning rate in beef breeds is typically less than 5%. The twinning rate in cattle that were used to initiate the Twinning Project at the USMARC in 1981, ranged from about 0.5% in British beef breeds, 1 to 2% in Continental breeds and 4% in some dairy breeds (Echternkamp and Gregory, 2002).

### **Genetic selection for twinning in cattle**

Most of early literature reports direct one towards pessimism rather than optimism for the success of selection in markedly altering twinning rate in cattle (Rutledge, 1975). As with many other reproductive traits, heritability, repeatability and variance of the trait are low. Literature estimates of heritability for twinning in cattle are around 0.10 (Van Vleck and Gregory, 1996; Gregory et al., 1997; Karlsen et al., 2000). However, one should not immediately dismiss such a trait from being a candidate for selection. Rutledge (1975) proposed that twinning rate in cattle could be increased to an economically viable level through genetic selection when multiple observations of ovulation rate are the primary selection criterion for replacement heifers and sires (i.e., ovulation rate of daughters and female siblings). His hypothesis was soon confirmed by the results of the Twinning Project at the USMARC (Echternkamp et al., 1990; Van Vleck and Gregory, 1996; Gregory et al., 1996; Echternkamp and Gregory, 2002). The rationale for using ovulation rate is that multiple ovulations must precede twinning. Because of the high genetic correlation ( $r_g > 0.75$ ) between ovulation and twinning rates, and because the mean of six ovulation rates is moderate to highly heritable ( $h^2 = 0.35$ ) repeated measurement of ovulation rate is effective as an indirect selection criterion for twinning rate (Gregory et al., 1997).

### **Problems associated with twinning in cattle**

#### *Fetal survival*

One of the problems associated with multiple fetuses in cattle is caused by the fusion of the chorionic blood vessels between the fetuses so that fetuses share a

common blood supply (Echternkamp, 1992). The consequences are increased fetal mortality and the freemartin syndrome in females born with a male. If a twinning technology is implemented, theoretically nearly one half of the females born as twins will be freemartin. Freemartins exhibit development of male's primary and secondary sex characteristics. Gregory et al. (1996) reported that more than 95% of females born co-twin to a male are freemartin and, thus, sterile. Kirkpatrick (2002), however, pointed out that freemartinism is more a perceived than a real problem because the number of fertile females produced from a twinning system will differ only a little from the number from a single-birth system. Placental fusion also increases fetal mortality because if one fetus in the placenta dies, the other fetus(es) also dies (Echternkamp, 1992).

### *Shorter gestation length*

Studies on twinning have reported that shorter gestation periods and lighter birth weights can be expected from gestations with twins rather than singles. Gestation length for twin births in cattle is approximately 5 to 7-d shorter than for cattle bearing singles (Turman et al., 1971; Bellows et al., 1974; Anderson et al., 1982, Echternkamp and Gregory, 1999a). Differences in gestation length between twin and single births likely contribute to some of the differences in calf birth weight in twin vs single pregnancies (Gregory et al., 1996).

### *Retained Placenta*

The incidence of retention of placental membranes is increased after a twin birth (Turman et al., 1971; Bellows et al., 1974) and is also increased after a twin birth with dystocia (Echternkamp and Gregory, 2002). Echternkamp et al. (1987) reported that premature induction of parturition in cattle will also increase the incidence of placental retention for singles. Since gestation length is about a week shorter for twin, this may account for part of the increase in incidence of retained placenta with twins (Echternkamp and Gregory, 2002). Placental retention associated with malpresentation dystocia, however, is substantially greater than the effect of gestation length. Echternkamp and Gregory (2002) further indicated that retention of placental membranes reduced subsequent conception rates by 7 to 8% after either a single birth or twin births.

### *Dystocia*

Reports on twinning have been generally consistent in identification of problems associated with twinning with one exception, that being dystocia. Kirkpatrick (2002) indicated that the inconsistency could be a reflection of two competing dynamics: "twinning reduces incidence of dystocia attributable to large calf size but increases incidence of dystocia attributable to malpresentation". The incidence of dystocia (no assistance vs assistance) is higher with twin births and differs in cause between single and twin births (Cady and Van Vleck, 1978; Gregory et al., 1996). The smaller twin calves have a lower incidence of births requiring traction but a higher incidence of malpresentations due to abnormal positioning of one or both calves in the birth canal (Echternkamp and Gregory, 2002). Dystocia reduces perinatal calf survival, especially for twins (Gregory et al., 1996; Echternkamp and Gregory, 2002). Kirkpatrick (2002),

however, suggested that in the event of potential malpresentation with twin calves, the cow should be penned and the calves repositioned prior to delivery.

#### *Increased interval from parturition to conception*

A longer interval from parturition to conception in dams of twins is well documented (Turman et al., 1971; Cady and Van Vleck, 1978, Guerra-Martinez et al., 1990; Kirkpatrick, 2002). Echterkamp and Gregory (1999b) reported a 12-d longer interval from parturition to the next conception for cows after giving birth to twins as compared to cows that carried only one calf. Kirkpatrick (2002) indicated that early weaning of calves (i.e., at 6 to 8 weeks of age or younger) has been well documented to improve postpartum reproductive performance, which could also be done with cows having twins.

#### **Effects of twinning on productivity**

Twinning might be reasonable to emphasize if the economic benefits from such research, if successful, might be very great. For example, Turman et al. (1971) reported that cows producing twins weaned an additional 171 kg of calf as compared to those weaning singles. Although twinning reduced calf survival, dams producing twins at birth weaned 70.8% more calves than dams with a single birth, which resulted in a 48.1% increase (335.7 vs 226.6 kg) in total weaning weight (Echterkamp and Gregory, 2002).

Gregory et al. (1996) compared growth traits of single and twin born calves and reported that twin calves were about 20% lighter at birth and about 10% lighter at weaning. They also pointed out that twin calves were lighter at slaughter, even though they were 3-wk older than single-born calves. Single born calves also had greater ADG both before (1.08 vs 1.01 kg/d) and after weaning (1.44 vs 1.39 kg/d) compared with twins. They postulated that the greater ADG reflects both pre- and postnatal maternal effects on calf growth.

Echterkamp and Gregory (2002) compared carcass traits of single- and twin-born steers. Although twins had less carcass weight (a reflection of their lighter slaughter weight), smaller rib eye area (REA) and smaller retail product percentage (RPP), both dressing percentage and estimated kidney, heart and fat percentage (KPH) were similar for the two groups. However, marbling was increased in the older twin carcasses with 6% ( $P < 0.05$ ) more of the twin carcasses achieving a USDA grade of Choice or above. Echterkamp and Gregory (2002) postulated that the increased marbling in twins could be a result of being fed the high-energy diet 3 wk longer and (or) from twins being less mature with less testicular growth and androgen production prior to castration. Hallford et al. (1976) indicated that carcass composition in cattle from multiple births is not deleteriously affected but that a longer time in the feedlot may be required before a desirable slaughter weight is reached.

Gregory et al. (1996) compared growth and carcass traits among single- and twin-born normal females and freemartin females. Freemartins were similar to normal females for growth traits, but freemartins had higher marbling scores and lower percentages of retail product.

Gregory et al. (1997) obtained positive but small estimates of genetic correlations in the range of 0.15 to 0.39 between growth traits (birth weight, 474-d weight, 566-d weight, and 4-yr-old weight) and both ovulation and twinning rates. Positive genetic correlations between fecundity and growth in cattle of such magnitudes tend to suggest that the beef industry would require little compromise when the selection goal is to increase twinning rate with little or no change in growth and mature size, especially in the cow herd.

Gregory et al. (1997) reported favorable estimates of genetic correlations between ovulation and twinning rates and scrotal circumference (0.29 and 0.38, respectively). The basis for their analyses was that scrotal circumference in males is genetically associated with age at puberty in heifers. Age at puberty seems to be associated with subsequent reproductive performance.

In general, twinning technology could be implemented without compromise of growth rate or carcass merit. The MARC twinning population was equal to or superior to a high performance reference population for growth and carcass traits (Gregory et al., 1996). Despite lower conception rates for dams of twins, the increased prolificacy provides an opportunity to increase total beef production with a twinning technology.

## **Summary and Implications**

Although production of twin calves presents a potentially new paradigm for beef cattle management and production and provides an opportunity to increase both reproductive and economic efficiency, some part of the potential economic gain is compromised by negative factors associated with the trait. These disadvantages include reduced calf survival, increased incidence of dystocia (due to malpresentations) and of retained placentas and longer intervals between conceptions. Kirkpatrick (2002) pointed out that some of these problems could be overcome with changes in management, that other problems lack an obvious management fix, and that still other problems are of little practical importance. Changes in management that may facilitate successful exploitation of twin births include pregnancy status checks to determine twin vs single gestations, adequate nutrition for twin gestations, adequate calving facilities, and early weaning of calves to facilitate rebreeding of the dam. Preparturient diagnosis of twin pregnancies would facilitate management at calving time to provide for timely administration of obstetrical assistance to facilitate delivery of twin calves and to increase their neonatal survival (Echternkamp and Gregory, 1999).

In recent years, new genetic technologies such as quantitative trait loci (QTL) identification, which may have application through marker-assisted selection (MAS) in livestock improvement programs, have been developed. Since selection response for reproductive performance has been quite limited because of the long generation interval needed for progeny testing and because of low heritability, these new approaches may lead to potential genetic benefits for beef producers. If loci affecting traits related to reproductive performance can be identified, then DNA markers might be used to select genetically superior animals and, thus, improve selection response.

Kirkpatrick (2002) hypothesized that different individuals or genetic lines of cattle may have varying predisposition to carry multiple fetuses successfully to term. Successful efforts to identify specific genetic loci controlling ovulation rate (Blattman et al., 1996; Kappes et al., 2000) may facilitate introgression of specific genes into different populations to test such hypotheses. Kappes et al. (2000), for example, suggested that a region in bovine chromosome 5 contains a gene or genes which are involved in the follicular recruitment and development process and thus would affect ovulation rate. However, as only a few important QTL have thus far been identified and sequenced, such innovative approaches have not yet had an impact on animal breeding. In the future, QTL may be identified which control critical components of ovulation, conception, and embryo/fetal survival associated with twinning.

In conclusion, twinning presents a potential means of dramatically improving efficiency of beef production. A high level of intensive management, however, is required for a twinning technology in cattle to increase economic productivity. Improvements in genetics and/or management for dystocia, calf survival and rebreeding rate will be required to make a production system based on twinning economically feasible. A complete economic assessment of twinning in beef cattle has not yet been conducted which is needed to determine if the economic returns from the production of two calves per cow crop could offset the costs of labor, feed and herd health (i.e., intensive management of twin-producing dams and their calves) as well as other disadvantages associated with the trait. Although the likelihood of achieving a workable system of twinning could be low because intensive management systems for beef cattle would seem to be unpractical in much of the U.S., there are regions where farmers have abundant feed resources and would be able to devote enough of their time to calving out cows prior to spring planting.

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