TWINNING IN BEEF CATTLE PRODUCTION SYSTEMS

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ABSTRACT

Successful reproduction of a cow-calf production system is the corner stone for biological and economical efficiencies. Cattle evaluations have focused mainly on production traits, consequently genetic improvement on reproductive traits through the use of selection tools is limited. Twinning is a complex trait with genetic- and physiological components affecting the trait. Furthermore, the reproduction of cattle is well dependent on several factors which includes species type i.e. *Bos taurus*, *Bos indicus*, breed, animal class and location. The interaction between environment, heath, genetic factors and management also influences occurrence, with multiple births most likely being due to multiple ovulations with a frequency not more than 1 %. With twinning as a trait, the heritability, repeatability and variance is very low. Some disadvantages associated with twinning includes infertility of the heifer calf, lower calf survival, increased culling rate, lower cow reproductive performance caused factors such as dystocia, gestation length and retained placenta. However, when raising twins a beef cow will most likely wean more total calf weight than a cow with only one calf. Therefore, twinning offers the potential for an increase in beef production efficiency in a herd. However, sustainable management practices must be implemented to handle the potential problems associated with twinning.

BACKGROUND

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 created the hope that it may also be successful in cattle, and South Africa is no exception. Beef cattle farmers have however, in general being opposed to twin births because of the number of problems associated with it. The problems include a higher incidence of calf mortality, dystocia, still births, abortions, calf abandonment, retained placentas, longer rebreeding intervals and the occurrence of freemartins.

Although the production of twin calves presents a potential new approach for beef cattle management and production and provides an opportunity to increase both reproductive and economic efficiency, some part of the economic gain is compromised by negative factors associated with the trait.

Most of the early literature report pessimism rather than optimism on the success to selection for twins. However such a trait should not be dismissed outright as a candidate for selection. With the development of new technologies such as Quantitative Trait Loci and Marker Assisted Selection, it may be possible to accelerate genetic improvement in twinning. If loci affecting traits related to reproductive performance can be identified, then DNA markers / genomic selection may be useful to select genetically superior animals and thus improve selection response.

This literature review is aimed at getting all the relevant fact together before any decision on possible research in this regard is taken, or advice is given to farmers.

INTRODUCTION

Successful reproduction of a cow-calf production system is the corner stone for biological and economical efficiencies (Dickerson, 1970). Cattle evaluations have focused mainly on production traits (Evans *et al*., 1999), consequently genetic improvement on reproductive traits through the use of selection tools is limited (Gutiérrez *et al*., 2002). Melton (1995) stated that in terms of an economic perspective, reproductive traits are twice as important as production traits within a cow-calf production system. Further, low heritability (MacNeil *et al*., 2006) of measured traits such as calving rate and days to calving (Meyer *et al*., 1990; Johnston & Bunter, 1996,) short controlled breeding seasons or the expression of a trait late in an animals' life has caused the improvement in reproductive efficiency to also be limiting (MacNeil *et al*., 2006). However, crossbreeding and management practices has been used to improve reproduction efficiency (Minick Bormann *et al*., 2006); nevertheless, insufficient amounts of direct selection thereof has been reported (Cammack *et al*., 2009). Twinning is a complex trait with genetic- and physiological components affecting the trait (Fricke, 2001).

Reproduction of cattle is well dependent on several factors which includes species type i.e. *Bos taurus*, *Bos indicus*, breed, animal class and location (Martin *et al*., 1992; Patterson *et al*., 1992; Lopez *et al*., 2006). Furthermore, the interaction between environment, heath, genetic

factors and management also influences reproductive performance (Gröhn & Rajala-Schultz, 2000; Roxström *et al*., 2001).

Cattle are uniparous species, hence females are likely produce only one offspring per pregnancy (Sreeman & Diskin, 1989; Komisarek & Dorynek, 2002). In most beef cattle breeds, twinning is a rare and unanticipated occurrence (Kirkpatrick, 2002), with multiple birth most likely being due to multiple ovulations (Sreeman & Diskin, 1989) with a frequency not more than 1 % (Rutledge, 1975). However, in dairy breeds the frequency of occurrences is between 3-5 % (Day *et al*., 1995; Komisarek & Dorynek, 2002; del Río *et al*., 2007). The regulation of twinning rate has previously been done by means of embryo transfer (Sreenan *et al*., 1975; Boland & Gordon, 1978; Anderson *et al*., 1979; Sreenan & Diskin, 1989), genetic selection (Van Tassell *et al*., 1998; Van Vleck *et al*., 1991b), hormonal treatments (45) or immunologic suppression of hormones (Wise & Schanbacher, 1983; Morris *et al*., 1993; Hillard *et al*., 1995).

In cattle, the incidence of twinning have will have advantages and disadvantages, depending on whether it is a dairy- or beef system as well as the production system in which the cattle are raised in (Komisarek & Dorynek, 2002). Twinning in beef cattle provide an opportunity to increase both the rate and efficiency of re-productivity (Guerra-Martinez *et al*., 1990). Furthermore, the prospective economic gain through twinning may be comprised by means of reduced survival rate, reduced birth weight of the twin calves and reduced weaning weight per calve (Gregory *et al*., 1996; Echternkamp & Gregory, 1999b). For a twin calf the time required in a feedlot may be longer until the required slaughter weight has been acquired (Hallford *et al*., 1976). Some researchers believe that twinning in beef cattle is a desirable trait (Guerra-Martinez *et al*., 1990; de Rose & Wilton, 1991.), whereas other believe it to be an undesirable trait (Cammack *et al*., 2009) due to the negative physiological aspects that accompanies twinning. Hence, this review provide a comprehensive overview of both the advantages and disadvantages of twinning in a beef production systems as well as the other influences that contribute to twinning rate.

GENETIC SELECTION AND OVULATION RATE

With twinning as a trait, the heritability, repeatability and variance is very low. With most reproductive traits, this is also the case (Van Vleck & Gregory, 1996; Gregory *et al*., 1997; Karlsen *et al*., 2000). Heritability (h^2) for twinning rate has been estimated to be lower than

0.01 to 0.09 (Syrstad, 1984; Cady & Van Vleck, 1978; Ron *et al*., 1990) However, Rutledge (1975) suggested that with genetic selection, twinning in cattle may be increased to a level with economic importance. This could be achieved through the use selection criterion primarily focussing on multiple observations of ovulation rate when applied to replacement heifers and sires. This was later confirmed by other authors as well (Echternkamp *et al*., 1990; Van Vleck & Gregory, 1996; Gregory *et al*., 1996; Echternkamp & Gregory, 2002). The genetic correlation between ovulation rate and twinning rate are 0.75 and higher (Morris & Day, 1986; Ryan & Boland, 1991; Van Vleck *et al*., 1991a; Gregory *et al*., 1997). In cattle, the rate of twinning is perceived to be quantitative trait. This implies that it is dependent of the combination of several genes modified by environmental factors (Komisarek & Dorynek, 2002).

For a realistic approach when using ovulation rate as selection criteria, multiple ovulations must be followed by multiple births. Repeated measurements of ovulation rate is effective as an indirect selection criteria due to two factors. Firstly, the high genetic correlation between twinning rate and ovulation rate ($r_g > 0.75$) and secondly, the mean of six ovulation rates has a moderate to high heritability ($h^2 = 0.35$) (Gregory *et al*., 1997). Lien *et al*. (2000) used a genome-wide linkage analysis and detected a quantitative trait locus (QTL) for twinning on chromosome 5 of the bovine genome. Further, Meuwissen *et al*. (2002) mapped the QTL for twinning to a marker interval between *CSSM22* and *ILSTS66* with this region being < 1 cM.

Multiple ovulations can occur on the unilaterally (same ovary) or bilaterally (both ovaries) (Echternkamp *et al*., 2007). Echernkamp *et al*. (2007) suggested that bilateral twins had better neonatal survival rates, higher birth weights and longer gestations lengths, compared to twins gestating in one uterine horn. Therefore, with the use of twinning technology, methods to increase the proportion of bilateral twin calves should be able to increase production gains (Echternkamp & Gregory, 2002; Cushman *et al*., 2005). Furthermore, the biggest increase is twinning generally occur between parity one and parity two. Twinning will also continue to increase with subsequent parities, however at a slower rate (Fricke, 2001).

DISADVANTAGES

Some disadvantages associated with twinning includes lower calf survival, dystocia, stillbirths, abortions, calf abandonment, retained placentas, increased culling rate (lower cow reproductive performance and freemartin heifers (Eddy et al., 1991, Fricke, 2001; Nephawe, 2002; Bell & Roberts, 2007). The lower productive performance in cows is mainly caused by

increased difficulties during the course of pregnancy in and increased calving period (difficult births) (Erb & Morrison, 1959). Further, with the increase in twin births in a herds, the risk of non-successful reconceptions increases and thereby the profitability of the herd decreases drastically (López-Gatius *et al*., 2002; Lopez-Gatius & Hunter, 2005).

It has been reported that cows calving twins have longer calving intervals and increased culling rates than cows carrying only one calve (Bicalho *et al*., 2007). In dams carrying twins, longer intervals between giving birth and conception has been well documented (Turman *et al*., 1971; Cady & Van Vleck, 1978; Guerra-Martinez *et al*., 1990; Kirkpatrick, 2002).

Twinning is also largely associated with cow productive performance which include increased dystocia (Ghavi Hossein-Zadeh, 2010), -mortality rates, -occurrences of freemartins, -incidences of retained placenta and extended interval from parturition to first estrous (Kirkpatrick, 2002; Echternkamp *et al*., 2007; del Río *et al*., 2007). In addition, twinning places the cow at greater risk for developing metabolic disorders such as ketosis and displaced abomasum (Laben *et al*., 1982; Nielen *et al*., 1989).

Gestation length

Gestation length is affected by twinning through the shortening thereof (Guerra-Martinez *et al*., 1990; Gregory *et al*., 1990; Echternkamp & Gregory, 1999a) which also possibly contributes to the increase in the frequency of retained placentas in cows (Echternkamp & Gregory, 1999a). The gestation length can be 5 – 7 days shorter for twin bearing cows than cows carrying only one calf (Turman *et al*., 1971; Bellows *et al*., 1974; Anderson *et al*., 1982, Echternkamp & Gregory, 1999a). In addition, the reduced birth weight of twin calves is probably the result of the shorter gestation length of the cows carrying twins (Day *et al*., 1995; Gregory *et al*., 1996).

Dystocia

Dystocia or, calving difficulty, can be scaled from little to no assistance during calving to a high level reflecting considerable amount assistance ore even caesarian operation (Meijering, 1984). It is well known that fertility is much lower after a caesarian operation due to dystocia (Dobson *et al*., 2001). Furthermore, calf survival is also frequently negatively associated with dystocia (Cundiff *et al*., 1986). Therefore, lower calf survival may be reflected by other measures of re-productivity such as calving rate (Cammack *et al*., 2009). Guerra-Martinez *et al*. (1990) observed the rate of dystocia was higher in heifers (28 %) than in cows (10 %). However, the authors also observed that the rate of dystocia is higher in heifers carrying one

calf than heifers carrying twins. In cows, dystocia associated with twinning is most frequently caused by malpresentation of the calves (Echternkamp & Gregory, 2002).

Freemartinism

Freemartin syndrome in heifers occurs from twinning. During gestation, when the cow is carrying dizygotic twins, i.e. female and male, the embryonic membranes of the two foetuses conceptus fuse. The result is the exchange of blood between the foetuses where endocrine factors or cells is transferred from the male to the female calf. This causes the abnormal development of the reproductive organs of the female calf and result in infertility (Muller, 1992; Ghavi Hossein-Zadeh, 2013). Only 8 % of heifers born from a heterosexual twin pregnancy will be normal due to the membranes failing to fuse or the fusion occurs only after the period of the reproductive organ development. The other 92 % of heifers born will show freemartinism (Buoen *et al*., 1992) and will threfore be infertile.

Retained Placenta

Retained placenta in cows is due to the phenomenon that not all of the parts of the placenta is delivered in the uterus during birth (Çobanoğlu, 2010). According to Erb & Morrison (1959) and Bendixen *et al*. (1987) several factors including disease, abortion, dystocia, twin birth, gestation length and nutrition influences the retention of placenta in cows. Penny *et al*. (1995) observed that 62 % of retained placenta incidences were caused by twinning. This in comparison of only 3 % in cows only carrying one calf. Also, this incidence of retained placenta is increasing after twin births (Turman *et al*., 1971; Bellows *et al*., 1974) as well as after a twin births experiencing dystocia (Echternkamp & Gregory, 2002). Furthermore, in beef cattle, Guerra-Martinez *et al*. (1990) observed the rate of incidence of retained placenta was in heifers calving twins were 25 % and cows calving twins 24 %. In comparison the incidence in heifers bearing one calf is 12 % and cows bearing one calf 4 %.

ADVANTAGES

Productivity and Profitability

In theory, beef cattle productivity in a herd can be improved in through the increase in prolificacy or the increase in the frequency of twins in the herd (Cammack *et al*., 2009).

When raising twins a beef cow will most likely wean more total calf weight than a cow with only one calf. Therefore, twinning offers the potential for an increase in beef production efficiency in a herd. However, sustainable management practices must be implemented to

handle the potential problems associated with twinning (Kirkpatrick, 2002). In a herd, increased twinning may allow the increase in progeny from a genetically superior cow, hence the female animals within a herds play a bigger role in the selection program (Cady & Van Vleck, 1978). Accompanying the latter are the application of technologies such as embryo technology and sexed semen which allow the regulation of the sex of the calves, thereby selecting more female calves (Ghavi Hossein-Zadeh *et al*., 2010) in dairy herds for example.

One of the most important factors affecting beef cattle production, is low reproductive performance. Expenses such as feeding and management systems of reproducing cows contributed mainly to production costs, hence the cause of reduction of the overall efficiency. Therefore, a cow producing an extra calf would potentially increase the production efficiency, since the extra calf will also be available for slaughter (Çobanoğlu, 2010). Gaafar *et al*. (2010) found that in comparison with single calves, Friesian twin calves had higher total body weight, higher total body weight gain, better feed conversion ratios and greater economic efficiency. Twin calves also had lower feed intake and feed cost.

Bar-Anan & Bowman (1974) illustrated the potential for a decrease in production costs of about 20-30 % per unit of beef returns, when an increase in total weight of calves is observed at weaning by the means of twinning. Furthermore, is was also observed that albeit twin calves have lower birth- and weaning weights, they also have higher growth rates than single calves after weaning (Guerra-Martinez *et al*., 1990). De Rose & Wilton (1991) observed that even though twins have shorter gestation lengths their combined birth weight is 25.5 kg more than that of single calves.

The comparison of weaning weights between twin and single beef cattle calves from different studies are presented below:

- (De Rose & Wilton 1991) found that twins produced 186.0 kg more weight at weaning per cow than cows with only one calve
- Turman *et al*. (1971) found that cows with twin calves produced an additional 171 kg of calf at weaning, compared to cows with single calves
- Davis *et al*. (1989) reported a 108 kg (51 %) increase in total weaning weight with cows producing twins compared to singletons.
- (Echternkamp & Gregory, 2002) found that dams with twins produced 70.8 % more calves compared to a single calve born. This resulted in an increase of 48.1 % in weaning weight.

It was suggested that 24 % lower input of production costs was necessary with single calving compared to twin births. The high healthcare expenses accompanying twin birth in beef cattle production should therefore be accounted for (Guerra-Martinez *et al*., 1990). A study conducted by Gregory *et al*. (1996) they found that a cow with twins, produced 65.2 % more live calves than a cow carrying one calve.

Many studies have also shown that female calves born with freemartin syndrome does not have a negative effect on a beef production systems, due to the larger amount of calves within a herd that is subjected to slaughter after weaning. Furthermore, in comparison with normal female calves, freemartins will frequently be more of choice grade carcass quality since more marbling is observed in the longissimus muscle (Çobanoğlu, 2010). Also, freemartins generally have a higher birth weight than normal female calves (Echternkamp & Gregory, 2002). In terms of carcass characteristics, it was found that no visible differences could be identified (Hallford *et al*., 1976; Echternkamp & Gregory, 2002).

CONCLUDING REMARKS

In beef cattle, the increase in prolificacy may increase the profitability (Echternkamp *et al*., 1999). Guerra-Martinez *et al*. (1990) found that twin calves had reduced birth weights of 13 % and at weaning a reduction in weight of 17 %. However, twins per cow produced total body weight of 140-179 % more than a cow with a single calve.

For a cow-calf production system to increase its efficiency, improvement in the fertility of both the cows and yearling heifers are required (Smith *et al*., 1989). Furthermore, female fertility is easily recognizable in measurable traits such as calving interval (Cammack *et al*., 2009). As management and feeding improved, the rearing rate of twins was increased. This was found by Hendy & Bouwman (1970) when it was realized that environmental factors influenced the rate of mortality in calves born as twins. They also suggested that the quantity and quality of feed can improve fertility, with the cow presumably being genetically predisposed to twinning.

The additional management practices when facilitating twinning is the accurate identification of cows gestating twins and assistance at parturition of the calves that will increase the neonatal survival of the calves (Komisarek & Dorynek, 2002). Furthermore, genetic selection applied to replacement heifers for twinning are based upon multiple observations of ovulation rate (Echternkamp & Gregory, 1999a). Therefore, by applying the appropriate

management practices to reduce the negative effects of twinning on the cow/heifer reproductive performance as well as the calve productive performance, twinning in a beef cattle production system has at least a theoretical potential to increase productive performance of a herd as well as increase the economic returns thereafter.

With the development of new genetic technologies such as quantitative trait loci (QTL) and marker-assisted selection (MAS) it may be possible to more effectively select for twinning in beef cattle. If loci affecting traits related to reproductive performance, including twinning, can be identified, such DNA markers will be useful to select genetically superior animals for a number of reproductive traits, thus improving response to selection.

SUMMARY AND IMPLICATIONS

Twinning in beef cattle, at least theoretically, presents a potentially new paradigm for beef cattle management and production systems. As such it provides an opportunity to increase both reproductive and economic efficiency, albeit that some of the potential economic gain will be compromised by factors negatively associated with the trait. The disadvantages include reduced calf survival, increased incidence of dystocia, retained placentas and longer intervals between conceptions.

Some of these problems can be overcome with changes in management, whereas other problems lack obvious management interventions. Changes in management that may facilitate successful utilization of twins include pregnancy status checks to determine twin versus single gestations, appropriate nutrition for twin gestations, suitable calving facilities, and the early weaning of twin calves to facilitate rebreeding of the dam (Nephawe, 2002). The pre-calving diagnosis of twin pregnancies will facilitate management at time of 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).

Twinning in beef cattle is a potential mean of dramatically improving efficiency of beef production. However, a very high level of intensive management will be required for the twinning technology in beef cattle to increase economic productivity. Improvements in genetics and/or management for dystocia, calf survival and rebreeding rate will be required to make any beef production system based on twinning economically feasible (Nephawe, 2002).

Nowhere has a complete economic assessment of potential of twinning in beef cattle been conducted. Such an assessment is needed to determine if the economic returns from the

production of two calves per cow crop could offset the costs of labour, feed and herd health (i.e., intensive management of twin-producing dams and their calves) as well as other disadvantages associated with the trait.

In South Africa the likelihood of achieving a workable system of twinning in beef cattle will be low because extensive beef production systems are dominating the beef cattle farming enterprises. However, there may be a few cases where beef cattle farmers have abundant feed resources and will be able to devote enough of their time to managing and caring for cows calving twins. Unfortunately, selection for twinning will be limited if small numbers of animals are available.

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