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Reproductive Performance of Friesian-Holstein Cows at Sebele Research Station in South Eastern Botswana

Research Article

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ABSTRACT

Retrospective data from Sebele Dairy Farm were analysed for reproductive performance of Friesian/Holstein cows. Three hundred records from 1989 to 1995 were used. The herd was zero grazed and the data was analysed for age at first calving (AFC), calf birth weights (BW), calving interval (CI), days open (DO), calving rate (CR), reproductive wastage (RW) and calving difficulty (CD); dystocia, after-birth retention and misrepresentation of foetus) and calving weights (CW). The effects of year of calving (YOC) and year of birth (YOB) were tested. The year of calving affected age at first calving (P<0.05) whereby in 1989/90 and 1990/91 cows were younger than the rest of the years. Calving weight at first calving was significantly affected (P<0.01) by year of calving. YOC had an effect (P<0.05) on both calving interval and days open. CW and CR were significantly affected (P<0.001 and more) by the year of calving. Reproductive wastage tended (P=0.065) to be affected by YOC while no effect (P>0.05) was observed for BW and CD. The year of birth of cows (YOB) had an effect (P<0.05) on age at first calving and it also significantly affected (P<0.01) CW of first calving heifers. Heifers born in the 1980's had lower live weight at calving than those born in the 1990's. Age categories (1=20–39 months; 2=40–69 months and 3=>70 months) tended (P=0.062) to influence the birth weights of calves. As cows' age increased, birth weights of their calves decreased. However, age category did not affect (P>0.05) calving interval or days open. Male calves were heavier (P<0.05) at birth than females (38.7±1.3 kg *vs.* 36.8±0.7 kg). CW was lower for heifers than for cows and represented 84% of the cows' weights. Heifers had higher (P<0.01) CR than cows (100 *vs.* 64.9%), however RW was higher (P<0.01) for heifers than cows (25.0 *vs.* 11.0%). RW was significantly correlated with birth difficulty (r=0.50; P<0.001). It seems that a low temperature-humidity index in the month of conception resulted in higher CR nine months later. It is recommended that when cows are zero grazed, feed quality should be assured by nutrient balancing and should not affect performance between years.

KEY WORDS age at first calving, calving rate, calving weight, days open, reproductive wastage.

INTRODUCTION

Reproductive performance of modern dairy cow is declining and is wide spread (Lucy, 2001; Löf *et al.* 2007). In an invited lecture at New Zealand Society of Animal Production conference, Lucy (2001) reported declining fertility in dairy cows in United States of America (USA), Ireland, United Kingdom (UK) and Australia. In Sweden, calving interval increased from 391 days during 1994/95 to 403 days in 2004/5 (Löf *et al.* 2007) while service per conception increased from 1.8 to 3 in dairy cows in USA (Washburn *et al.* 2002). In other parts of the world such as the tropics, decreased reproductive performance of dairy cows has also been reported (Ageeb and Hayes 2000;

Soydan *et al.* 2009; Ansari-Lari *et al.* 2010; Tadesse *et al.* 2011; Gwaza *et al.* 2011; Fekadu *et al.* 2011). It is not yet clear which factors cause or predispose the modern dairy cow to reduced fertility. Factors contributing to decreased fertility are likely to be dissimilar in different regions of the world.

For instance, in the Northern Hemisphere (North America and Europe) the genetically driven increase in milk production has been implicated due to its predisposing negative effects on energy balance (Butler *et al.* 1996; Grohn and Rajala-Schultz 2000; Tamminga, 2006). However, in south Africa, Muller *et al.* (2000) observed that relationship between milk yield and reproduction was relatively low. Elevated blood protein metabolites (urea and ammonia) emanating from highly degradable protein diets have also been implicated in decreased conception rate (Canfield *et al.* 1990) and decreased pregnancy rate (Butler *et al.* 1996; Rhoads *et al.* 2006) in stall-fed cows in the northern Hemisphere.

In contrast, recent studies found no evidence of detrimental effects to reproduction in New Zealand dairy cows grazing high quality pasture (Madibela *et al.* 2008; Ordonez *et al.* 2007) as it was observed in cows grazing high protein pasture in Ireland (Kenny *et al.* 2001). Therefore, for cows in other regions of the world outside northern Hemisphere other factors may be involved.

These other factors include periparturient diseases Lourens (1995), heat stress (Kadzere *et al.* 2002; De Rensis and Scaramuzzi 2003; Soydan *et al.* 2009; Avendano-Reyes *et al.* 2010), poor efficiency of heat detection (Tadesse *et al.* 2011; Gwaza *et al.* 2011; Fekadu *et al.* 2011) and poor feeding regimes (Fekadu *et al.* 2011; Gwaza *et al.* 2011). There is currently no information on the reproductive performance of dairy cows in Botswana. This study evaluated, using retrospective data, the reproductive performance of Friesian-Holstein cows under zero grazing in south eastern Botswana.

MATERIALS AND METHODS

Location and climate

The data for this study were obtained from records kept by the Sebele Research Station dairy farm covering the period 1989/90 to 1994/95. This Friesian-Holstein herd was established from off springs of a foundation stock of 30 cows bought from south Africa in 1979.

During the period under analysis the dairy cows were maintained at 50 animals; however, because of missing data, records used in the present study may not reflect this number. Daily maximum and minimum temperatures and relative humidity were obtained from Sebele Meteorology Station and these were used to estimate temperature humidity index.

Sebele Research Station is located in Gaborone city at a latitude of 24 ˚33' S and longitude of 25 ˚57' E with an altitude of 994 m above sea level. The temperature during the cooler months (May to August) averaged 24.2 ˚C during the day and 6.2 ˚C at night during the study period (1989/90-1994/95). During the hot months (September to April) maximum and minimum temperature was 31.4 and 16.8 ˚C respectively. Relative humidity during this period was highest (62.3%) at 0800 h CAT during the hot months and lowest (29.7%) at 1400 h CAT during the cooler months.

Management practices during the period of data collection

Animals were zero grazed. Milking cows were fed on average 6.0 kg Lucerne hay (*Medicago sativa*), 4.0 kg brewers' grain and 3.0 kg of home-made dairy meal. When lucerne was not available lablab (*Dolichus purpuresus*) hay was fed instead. When maize (*Zea mays*) silage was available it was also fed to lactating cows. Dry cows were fed cenchrus hay (*Cenchrus ciliaris*) and brewer's grain. The milking cows were divided into two groups. The first group consisted of high producers and cows in early lactation while the second group had low producers and cows in late lactation. The second group was milked last to avoid possible contamination of milking equipment with udder infection since cows in late lactation are prone to mastitis. Dry cows were managed together with pregnant heifers. Young females were fed grass hay, brewer's grain and lucerne hay until they were bred. Water was available all the time. Artificial insemination (AI) was used for breeding using imported Friesian-Holstein semen from south Africa. According to the management plan heifers were first bred when they were 320 kg at 15 months of age. Newborn calves were allowed to suckle colostrum for 4 days after which the calf was separated from dam and bucket-fed whole milk. Calves were reared in individual calf pen separated by mesh wire to enable them to see each other thus reducing stress but preventing them from suckling each other's navel. The concrete floor had grass hay as bedding, which was changed weekly. After three weeks milk replacer was gradually introduced while the amount of milk was reduced. At 4 week of age, calf starter (18% crude protein (CP)) and lucerne hay was introduced and increased while the amount of milk replacer was reduced. At 3 months, calves were weaned from liquid, fed solely on solids and were managed as a group until 7 months when the males would be separated from females.

Cows were machine milked twice a day at 06.00 and 15.30 hrs. Dairy meal not exceeding 3 kg was fed in the milking parlour. After being milked, cows were released into their respective paddocks, where they were fed cenchrus hay. Indigenous Acacia trees provided shade in the paddocks. Routine disease control was carried according to APRU (1981).

Parameters studied

Parameters studied included age at first calving, calf birth weights, calf weight gain, calving to conception interval (days open). The calving interval, reproductive wastage and calving difficulty were assessed. Calving difficulty included scores due to dystocia, after-birth retention and misrepresentation of foetus while reproductive wastage included still birth, abortion and death in the first 24 hours where abnormal condition was scored 1 and the normal condition was scored zero. Instead of parity, age was used and cows were grouped in arbitrary categories due to variation in age within parity as follows; 1= 20 to 39.9 months, 2= 40 to 69.9 months and 3= 70 or more months.

Data analysis

Total number of individual records was 300 but the number for different analysis may be lower due to missing data in some instances. Data were analysed for the effects of year of calving and year of birth on age at first calving, calf birth weights and calving interval using General Linear Models (GLM) procedure of the Statistical Analysis System (SAS, 1990). The effects of year of calving on calving rate, reproductive wastage and calving difficulty were evaluated by frequency analysis, using a Chi-square test (SAS, 1990) Analysis of variance (ANOVA) was used to assess the effects of calf's sex and year of birth on calf birth weights and average daily gain. The temperature-humidity index (THI) was derived from temperature and humidity data and the indices were extrapolated from critical temperature zones for dairy cows established by Department of Agricultural Engineering, University of Arizona, Tucson, Arizona, United States of America which used the formula; (0.8×dry-bulb temperature) + (relative humidity×(air temperature-14.4)) + 46.4 (Moran, 2005). The THI were then plotted against CR with its respective month of conception in an attempt to identify period of stress.

RESULTS AND DISCUSSION

Results on the effects of year of calving on age at first calving, calving weight and calf birth weight are shown on Table 1. Year of calving had an effect (P<0.05) on age at first calving. During the years 1989/90 and 1990/91 first calving heifers were younger than on the other years in the study. Year of calving also significantly (P<0.01) affected the calving weight of first calving heifers. The weight of the heifer at calving increased as the years progressed from 1989/90 to 1994/95. Year of calving did not (P>0.05) have an effect on birth weight of calves.

The results of effects of year of birth on age at first calving and calving weight are shown on Table 2. Year of birth had an effect (P<0.05) on age at first calving and it also had a significant (P<0.01) effect on calving weight of first calving heifers. Heifers born in the 1980's had lower weight at calving than those born in the 1990's. Age category of the dam tended (P=0.062) to influence birth weight of calves. Cows in age category 1 gave birth to calves with average weight of 38.8 ± 1.2 kg, while those in category 2 calved offspring with weights of 38.6 ± 0.9 kg and cows in category 3 had calves weighing 35.8 ± 1.3 kg. The calves gender influenced (P<0.05) the calf birth weight; 36.8 ± 0.7 kg and 38.7 ± 0.8 kg for females and males respectively.

The results of effects of year of calving on calving interval and days open are shown on Table 3. Year of calving and weight at calving had an effect (P<0.05) on calving interval and days open. Neither age at first calving nor age category affect (P>0.05) the calving interval (405.3±10.0 *vs*. 389.17 for category 2 and 3 respectively) and the days open (85.3±10.0 *vs*. 69.7±17.7 for category 2 and 3 respectively).

The results for the effects of year of calving on calving weight (CW), calving rate, reproductive wastage, and calving difficulty for heifers and adult cows are shown in Table 4. The weight at calving was significantly lower (P<0.001) for heifers than in adults corresponding to 84% of the weight of mature cows.

Heifers showed higher (P<0.01) calving rate than cows (100 *vs*. 64.9%). Reproductive wastage was however higher (P<0.01) for heifers than adult cows (25.0 *vs*. 11.0%). Calving difficulty was similar (P>0.05) between heifers and cows (15 *vs*. 8.5%).

Birth weight of calves was correlated (r=0.24; P<0.001) with calving weight. Reproductive wastage was correlated (r=0.14; P<0.05) with the female´ age category. However, calving difficulty was not related to age category (r=-0.02; P<0.05). Calving rate tended to be higher when temperature-humidity index during the month of conception was low (Figure 1). The mean value of AFC in the present study is lower than the reported recently for dairy cattle in Ethiopia: 40.2 months in Holstein-Friesian cattle three herds in Addis Ababa (Tadesse *et al*. 2011) and 42.2 months for another herd in Rift Valley (Fekadu *et al*. 2011). There was no apparent trend in AFC across years of calving in the present study, but Tadesse *et al*. (2011) and Fekadu *et al*. (2011) found a decrease in AFC in Holstein-Friesian heifers in Ethiopia. According to Tadesse *et al*. (2011) this might be due to improved heifer management and earlier mating of breeding heifers.

The AFC of 36 months observed in the current study is not the ideal. Heindricks (1996) recommend that AFC should be 24 months.

Table 1 Effect of the year of calving on the age at first calving, the weight at first calving and on the calf birth weight of calves

Parameter	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	SL
Age at 1^o calving (months)	31.6±2.1^b	29.1±3.6^b	38.4±2.3^a	38.8±1.6^a	39.4±2.3^a	38.4±2.1^a	P<0.05
Weight at calving (kg)	470±23.7^{bcd}	390±41.1^d	439±29.1^{cd}	490±18.4^{bc}	542±29.1^{ab}	557±23.7^a	P<0.01
Calf birth weight (kg)	37.6±1.0	36.8±1.3	37.1±1.3	39.5±1.5	37.9±1.2	37.5±1.1	P>0.05

SL: significant level.
1^o: first.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Table 2 Effect of year of birth on age at first calving and calving weight of heifers

Parameter	1987	1988	1989	1990	1991	1992	SL
Age at 1^o calving (months)	31.6±2.1^c	41.0±2.6^{ab}	34.7±2.0^{bc}	39.5±1.7^{ab}	39.6±2.3^{ab}	35.3±30^{bc}	P<0.05
Weight at calving (kg)	470±22.9^{bcd}	435±32.4^{cd}	430±22.9^d	517±18.7^{ab}	574±25.1^a	515±32.4^{bc}	P<0.019

SL: significant level.
1^o: first.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Table 3 Effect of year of calving on calving interval and days open of Friesian-Holstein cows

Parameter	1990/91	1991/92	1992/93	1993/94	1994/95	SL
Calving interval (days)	367±16.8^c	400±15.5^a	391±17.9^b	394±16.3^b	436±15.2^a	P<0.05
Days open (days)	46.8±16.8^d	79.7±15.5^b	70.8±17.9^c	74.0±16.3^c	116±15.2^a	P<0.05

SL: significant level.
1^o: first.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Table 4 Effect of year of calving on calving weight (CW), calving rate, reproductive wastage, and calving difficulty of heifers and cows

Parameter	89/90	90/91	91/92	92/93	93/94	94/95	SL
CW (kg)	513.3±9.6^c	495.0±12.7^c	489.5±11.7^c	532.9±10.3^{ab}	550.7±12.1^{ab}	587.2±10.3^a	P<0.001
Calving rate (%)	96.0^a	55.3^d	67.4^c	78.9^b	60.0^{cd}	78.4^b	P<0.01
Reproductive wastage (%)	6.3	4.0	18.8	22.0	13.8	25.6	P=0.065
Calving difficulty (%)	8.5	7.7	9.4	11.4	14.3	11.8	P>0.05

SL: significant level.
1^o: first.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Late calving means that heifers would stay longer in the herd before being productive and thus will contribute to high feed costs (Frickle, 2004). In addition, heifers calving earlier at 23 months produce more milk in their lifetime than those calving later (Muller and Botha, 2000). The reasons for high AFC may be attributed, according to Gwaza *et al.* (2011), to environmental direct effects on the animal such as heat stress and indirectly through reduced pasture availability and its nutrient profile. Irregularities in nutritional conditions and feed supply during the early growth period before conception would have detrimental effects on AFC (Fekadu *et al.* 2011). In general, least cost formulation assumes a perfect knowledge of the composition of each ingredient, but the composition is usually estimated from standard tables or from a sample submitted for analysis, and in either case uncertainty about the true composition of ingredients still remains (St Pierre *et al.* 1986). Regardless of existence of this uncertainty, one would expect that dairy managers are able to get a grip on the balance of nutrients required so that irrespective of variation in season and in-turn in nutrient composition of pasture, cows still receive diets that meet their requirements for maintenance, lactation and reproduction. This is particularly true for zero grazed herds where other ingredients could be sourced to formulate balanced rations.

Therefore, cows in this study are expected to be less prone to suffer from seasonal variation of pastures since they were zero grazed. In the present study, AFC was also affected by year of birth of cows. In some years AFC was lower while in some years it was higher, (i.e. 1987; 31.7 months) but cows born in 1990/91 calved first when there were 40 months old. This may indicate deterioration of breeding practices (Fekadu *et al.* 2011). It may also suggest sub-optimal growth rates in growing heifers resulting in late attainment of sexual maturity than it is recommended. Dairy heifers should be fed so that they are ready to breed at 13-15 months of age (Heinrichs, 1996). Unlike in spring-calving dairy systems of Australia, Ireland and New Zealand where a compact breeding is practised and replacement heifers deemed too young to breed are not bred until the following season, at which time they may be over 30 months (Evans *et al.* 2006), in a continuous breeding such as practised in the present study, managers are not constrained by the breeding season and technically there is no reason to have longer AFC. In the present study, growth rates were affected by the year of calving and hence there was a variation in daily gains across the years, which was lower than 0.7 kg/d. Muller and Botha (2000) reported higher growth rates than those observed in the current study.

Heinrichs (1996) attributed increased AFC to an inadequate feed management of heifers. As AFC increases, there are older heifers in the herd beyond the optimum number of heifers needed to maintain a static herd size, therefore increasing the rearing costs (Frickle, 2004).

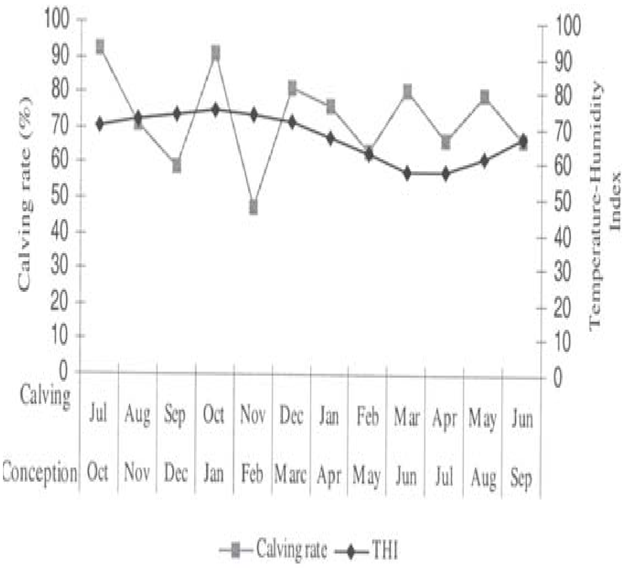

Figure 1 Temperature-humidity index (THI) during the month of conception and calving rate nine months later

The weight of first calving heifers can be used as a proxy for growth performance. In the present study, year of calving and year of birth of heifers affected calving weight. Interestingly, calving weight increased with progression of the period under study. Heifers that calved in the late 1980's and early 1990's had attained 92% of adult body weight when they calved and this proportion increased to 94% during the 1994/95 calving season. These observations suggest an improvement in heifer nutrition and hence of the growth rate and is in contrast to growth of female calves as discussed above. In addition AFC was not optimal as already observed above, which may suggest that other factors than nutrition were responsible for reproductive inefficiency.

Management has been cited (Ansari-Lari *et al.* 2010; Tadesse *et al.* 2011; Fekadu *et al.* 2011) as a contributing factor in reducing reproductive performance, including increase in AFC. Such management factors include poor oestrus detection by herdsman (Lucy, 2001; Tadesse *et al.* 2011; Fekadu *et al.* 2011), service irregularities and record-keeping problems (Fekadu *et al.* 2011), delayed breeding decisions (Ansari-Lari *et al.* 2010). Generally, breeding of dairy heifers should start when heifers reach 60% of their mature body weight (Fricke, 2004) and are large enough to calve without difficulty, around 24 months of age (Heinrichs, 1996).

In the present study progressive improvement in calving weight of heifers was correlated with birth weight of their calves, suggesting improved foetal growth as dam parturition weight increases. However there was a tendency for older cows to give birth to small calves and this is contrary to expectations. Age-related differences would be due to competition of resources for growth and reproduction in younger cows and lack of therein in adults.

Calving interval is commonly used to measure reproductive efficiency of dairy cows because cows that spend more time in non-productive period increase cost in terms of feed expenditure and lost revenue due to unavailability of saleable milk. Löf *et al.* (2007) in Sweden recorded an increase in CI from 391 days in 1994/5 to 403 days in 2004/5. This trend has also been observed in Ireland (Evans *et al.* 2006), in the Rift Valley Region of Ethiopia (Fekadu *et al.* 2011), in Iran (Ansari-Lari *et al.* 2010), the Central Sudan (Ageeb *et al.* 2000) and in USA (Lucy, 2001). These reports are consistent with the results obtained herein, where CI increased from 367 days in 1990/91 to 436 days in 1994/5. Days open (DO) concurrently increased with CI by 2.5 times during the period under study. Data for DO corroborate those observed by Ageeb *et al.* (2000), Ansari-Lari *et al.* (2010), Avendano-Reyes *et al.* (2010) and Fekadu *et al.* (2011). Generally, a DO increase contributes to the extension of CI and can be shortened by improved management practices (Fekadu *et al.* 2011).

The ideal DO should be of 42 days; in the present study DO was 46.8 days during 1990/91, but deteriorated in 1994/95 to 116 days. This suggests possible management practices that were not ideal, which may include deliberate decisions by management to delay breeding (Löf *et al.* 2007) of high yielding cows. However, previous work (Madibela *et al.* 2005) reported milk yield of 14.7 kg/day for this herd. Some of the factors identified to increase both CI and DO are dystocia (Evans *et al.* 2006), increased negative energy balance (Tadesse *et al.* 2011), increased imported genetics with high merit for milk production (Evans *et al.* 2006; Gwaza *et al.* 2011), poor heat detection (Tadesse *et al.* 2011), high ambient temperature which affect embryo survival (Kadzere *et al.* 2002; De Rensis and Scaramuzzi, 2003) and disease (Lourens, 1995; Ansari-lari *et al.* 2010). Contrary to increase in CI reported in the present study and from others studies discussed above, Tadesse *et al.* (2011) reported reduction in CI and attributed it to improved management and ability by animals to adapt to prevailing environmental conditions. Interestingly, Fekadu *et al.* (2010) observed decreased CI as age of cows increased up to 4th parity and this was ascribed to the inability of primiparous cows to meet their nutrient requirement for re-breeding activities.

Calving rate was affected by year of calving with very low rates in 1990/91. No tangible reason can be advanced for this observation. Heifers were found to have high CR than cows, which was also previously observed by Soydan *et al*. (2009) who attributed this finding to accrued steroid metabolism resulting in low circulating reproductive steroids due to high feed intake in older cows.

In the tropics high ambient temperature may affect reproduction (Fekadu *et al*. 2011) by reducing the degree of dominance of selected follicle (De Rensis and Scaramuzzi, 2003) and compromising embryo survival (Kadzere *et al*. 2002; De Rensis and Scaramuzzi, 2003). In the present study, it was found that when THI was low during month of conception, CR nine months later tended to be higher (Figure 1). This may be indicating effects of heat stress on postpartum reproductive efficiency (Avendano-Reyes *et al*. 2010).

Reproductive wastage increased with progression in year of calving and was also higher in heifers than cows. This may reflect an inadequate management or the inability of the breed to adapt to stressful environmental conditions and that the heifers are more likely to be affected than adults. Calving difficulty did not change significantly and this may suggest ideal selection for first time heifers. Avendano-Reyes *et al*. (2010) observed that calving difficulty was prominent in heifers than adult cows. Calving difficulty has profound negative effects on lifelong productivity of cows and has been associated with prepartum heat stress (Avendano-Reyes *et al*. 2010).

CONCLUSION

Results from the present study show sub-optimal reproductive performance. Though dam calving weight increased during the period under study suggesting little negative nutritional impact, AFC, CI, DO and reproductive wastage was not optimal. This suggests inadequate reproductive management and possible effects of heat stress.

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