SOURCES OF VARIATION IN CALVING DIFFICULTY IN BEEF HEIFERS

U. Paputungan, M. Makarechian and M. F. Liu[1]

Department of Animal Science, University of Alberta
Edmonton, Alberta, Canada T6G 2P5

Summary

Calving records of 107 heifers from two breed groups were used to identify the major factors contributing to calving difficulty (dystocia) and compare the influence of pelvic diameters, weight and height of heifers measured after breeding and before calving on dystocia. The horizontal and vertical pelvic diameters, hip height and weight of heifers were measured two months after breeding and again two months before calving. Snell transformed calving difficulty scores (0 = normal to 100 = surgical intervention) were used in analyzing the data by analysis of covariance. Body condition score of the heifer, sire birth weight of the calf, birth weight of the calf, and ratio of calf birth weight to pelvic area all had significant effects on dystocia. Calf birth weight, ratio of calf birth weight to pelvic area, and heifer's condition score were especially important. However, sex of calf did not have a significant influence on dystocia. Generally, the variables measured before calving accounted for a higher proportion of variation in dystocia than those measured after breeding. Thus, based on the relative importance of the major factors affecting dystocia, it is suggested that selection of bulls with low birth weight for breeding on normal size heifers with optimum body condition score, and well developed pelvic opening, would be effective in reducing the incidence and severity of dystocia in beef heifers.

(**Key Words**: Beef Heifers, Pelvic Measurements, Dystocia)

Introduction

The importance of calving difficulty (dystocia) in primiparous heifers as a cause of calf mortality, morbidity (Laster and Gregory, 1973; Bellows et al., 1987), increased management cost (Meijering, 1984) and low fertility in later parities (Brinks et al., 1973; Philipsson et al., 1979) is well documented. Published reports have indicated that the small pelvic area of primiparous heifers is a deterrent to normal parturition (Makarechian and Berg, 1983; Johnson et al., 1988). There have been several studies dealing with factors affecting calving difficulty with conflicting results. For example, calf birth weight was reported to be the most important factor influencing calving difficulty, while there was little or no correlation between pelvic measurements and calving performance (Van Donkersgoed et al., 1990). Morrison et al. (1985) reported that pelvic measurements accounted for 22.1% of the variation in calving difficulty score, although the effect of calf birth weight on calving difficulty was much more important than pelvic measurements.

Several researchers have identified feto-pelvic incompatibility as a major cause of dystocia (e.g. Deutscher, 1985; Johnson et al., 1988). However, pelvic measurements taken before or after calving may not accurately reflect the size of the pelvic inlet during fetus expulsion (Meijering, 1984). The changes in pelvic dimensions, hip height and weight of heifers during the period of pregnancy as they relate to calving difficulty have not been fully explored.

The objectives of this study were to identify the major factors contributing to calving difficulty and to compare the influence of pelvic diameters, weight and height of heifers measured after breeding and before calving on dystocia in beef heifers calving at two years of age.

Materials and Methods

Calving records of 107 heifers (born in the spring of 1990) from the University of Alberta Beef Cattle Research Ranch at Kinsella, Alberta, Canada were used in this study. The heifers were

[1]Address reprint requests to Dr. M. F. Liu, Beefbooster Management Ltd., 1935-32 Avenue N.E., Calgary, Alberta, Canada T2E 7C8.

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from two breed groups, 57 Beef Synthetics from the Beef Synthetic #1 line (SY#1), and 50 Dairy Synthetics from the Dairy Synthetic line (DS). The SY#1 line was composed of approximately 1/3 Charolais, 1/3 Angus, 1/5 Galloway with small contribution from Brown Swiss, Hereford, Holstein and Brahman breeds. The DS line contained approximately 2/3 Dairy breeding (Holstein, Brown Swiss and Simmental) and the remainder from traditional beef breeds. Details of the herd management and breeding composition have been described by Berg et al. (1990).

The heifers were mated with 7 yearling bulls (4 SY#1 and 3 DS bulls). The number of heifers mated to each bull ranged from 8 to 26 in single sire mating groups within each breed group for a period of 45 days and were maintained together until calving under conventional management. Bulls with extreme birth weights were not used for breeding.

The pelvic diameters, hip height and body weight of the heifers were measured first two months after the end of breeding season (18 $\pm$ 0.5 months old). Horizontal and vertical pelvic diameters (pelvic area = horizontal $\times$ vertical) were measured by a single operator using a Rice pelvimeter. Pelvic diameters, hip height and heifer weight were also measured two months before calving (22 $\pm$ 0.5 months old). The vertical pelvic diameter was measured as the perpendicular distance between the symphysis pubis and the sacral vertebrae, and the horizontal pelvic diameter was measured as the largest distance between the right and left shafts of the ilia. The hip height was measured as the vertical distance from the ground to the top of the hip.

Breed group, heifer's body condition score, sex of calf, calf birth date, calf birth weight, and sire birth weight were also considered in the study in order to evaluate their effects on calving difficulty.

Calving difficulty was scored on a 0 to 5 point scale, where 0 represented normal calving and 5 indicated the most difficult calving, requiring surgical intervention. Since there was only one calving difficulty of score 3 (hard pull), it was combined with score 2 (easy pull) category. There was no calving scores of 4 (veterinary assistance) and 5 (surgical intervention) in the data set. Heifer's condition was scored at calving on a 1 to 5 point scale, representing extremely thin to extremely fat animals respectively. There was no condition score of 5 in the data set.

The calving difficulty scores were first transformed using Snell transformation to provide homogenous residual variation over subclasses and approximately normally distributed residual deviations (Tong et al., 1977). The calving difficulty scores, the Snell transformed scores, and their frequencies are presented in table 1. Analyses were performed on the transformed scores.

The data were analyzed by analysis of covariance using SAS package (SAS Institute Inc. 1985). The following basic model was used to analyze the data:

$$Y_{ijkl} = \mu + B_i + S_j + C_k + \sum b_t X_{t(ijkl)} + \varepsilon_{(ijkl)}$$

where Y_{ijkl} was Snell transformed calving difficulty score, μ was the overall mean, B_i was the effect of the i-th breed group, S_j was the effect of the j-th sex of calf, C_k was the effect of the k-th body condition score, b_t was partial regression coefficient of calving difficulty score on the t-th continuous independent variable ($X_{(ijkl)}$), and $\varepsilon_{(ijkl)}$ was a random error.

Six submodels all based on the above basic model were used to analyze the data in order to identify and compare the variations in calving difficulty explained by the original variables and ratios of some variables measured on heifers two months after the end of breeding season and two months before calving season. In Model Ⅰ, breed group, heifer's body condition score, calf birth date and birth weight, heifer's pelvic area, hip height and body weight all measured two months after breeding were considered as independent variables. In Model Ⅱ, breed group, heifer's body condition score, calf birth date and birth weight, heifer's pelvic area, hip height and body weight all measured two months before calving were considered as independent variables. In Model Ⅲ, breed group, heifer's body condition score, calf birth date, ratios of pelvic horizontal and vertical to hip height, ratio of body weight to hip height and ratio of calf birth weight to pelvic area all measured two months after breeding were considered as independent variables. Model Ⅳ was similar to Model Ⅲ with the exception that the heifer's traits were measured two months before calving. In Model Ⅴ, breed group, sex of calf, heifer's body condition score, calf birth date, sire birth weight, heifer's pelvic area, hip

height and body weight all measured two months after breeding were considered as independent variables, and Model VI was similar to Model V except that the heifer's traits were measured two months before calving.

The contribution of a factor to calving difficulty was estimated as the percentage of the sum of squares (due to the factor after adjusting for the other factors in the model) in the corrected total sum of squares. This was equivalent to the reduction in the coefficient of determination (R^2) after dropping that factor from the model.

Results and Discussion

The frequency of normal calving in this study was 74% (table 1). The means of continuous variables of heifers taken after breeding and before calving are presented in table 2. Generally, the means of pelvic dimensions, hip height and weight of the DS heifers were higher than those of SY#1 heifers ($p < 0.05$).

TABLE 1. DESCRIPTION OF CALVING DIFFICULTY SCORES, THEIR FREQUENCIES AND SNELL TRANSFORMED SCORES IN BEEF HEIFERS

Calving description	Difficulty score	Frequency %	Snell transformed score
Normal	0	74	0
Slight assistance	1	12	60
Puller used, easy or hard	2	14	100

TABLE 2. LEAST SQUARES MEANS AND STANDARD ERRORS OF HEIFER TRAITS TAKEN TWO MONTHS AFTER BREEDING AND TWO MONTHS BEFORE CALVING AND THEIR COEFFICIENT OF CORRELATION

Breed[a]	No.	Variable[b]	After breeding Mean ± S.E.	Before calving Mean ± S.E.	Coefficient of correlation
SY#1	57	Pelvic horizontal (cm)	13.1 ± 0.07	15.7 ± 0.12	0.78***
		Pelvic vertical (cm)	15.8 ± 0.08	18.5 ± 0.09	0.73***
		Pelvic area (cm^2)	207.8 ± 2.11	291.5 ± 3.33	0.80***
		Hip height (cm)	126.3 ± 0.51	129.7 ± 0.51	0.92***
		Heifer weight (kg)	389.1 ± 4.36	442.1 ± 5.17	0.65***
SD	50	Pelvic horizontal (cm)	13.6 ± 0.08	16.3 ± 0.13	0.71***
		Pelvic vertical (cm)	16.3 ± 0.08	19.0 ± 0.10	0.53***
		Pelvic area (cm^2)	222.4 ± 2.25	309.7 ± 3.55	0.72***
		Hip height (cm)	130.7 ± 0.45	133.9 ± 0.55	0.87***
		Heifer weight (kg)	403.6 ± 4.65	454.8 ± 5.52	0.94***

[a] SY#1 = Beef Synthetic #1; SD = Dairy Synthetic.

[b] Significantly different ($p < 0.05$) between two breed groups for all variables.

*** Significantly correlated ($p < 0.01$) between variables measured after breeding and before calving.

The means of pelvic dimensions, hip height and weight of heifers increased in the two breed groups during pregnancy, following a similar growth pattern. There were moderate to high correlations between measurements taken after breeding and those taken before calving (table 2). The heifer's traits measured after breeding and before calving also showed somewhat variation, as indicated by the standard errors (table 2).

Comparisons of the total variation in calving difficulty scores explained by the models which included the variables measured after breeding with those which included the same variables measured before calving indicated that, in general, the variables measured before calving accounted for a somewhat higher proportion of variation

in calving difficulty than those measured after breeding (table 3). The total variation in calving difficulty accounted for the this study was higher than that previously reported by Naazie et al. (1989).

TABLE 3. VARIATION IN DYSTOCIA EXPLAINED BY INFLUENCING VARIABLES

Variable	Change in R^2 (%) After breeding[a]	Before calving
	Model I	Model II
Breed group	3.52*	3.61*
Body condition score	4.99*	6.10*
Calf birth date	2.33	2.95*
Calf birth weight	12.87**	15.97**
Pelvic area	0.68	0.04
Hip height	1.36	1.05
Weight	0.18	1.37
Total variation explained	35.51	36.17
	Model III	Model IV
Breed group	3.40*	2.93*
Body condition score	4.90*	5.16*
Calf birth date	2.30	3.13*
Pelvic horizontal/Hip height	2.13	2.94*
Pelvic vertical/Hip height	0.00	0.02
Weight/Hip height	1.08	1.53
Calf birth weight/Pelvic area	13.15**	17.57**
Total variation explained	35.61	37.29
	Model V	Model VI
Breed group	6.73**	7.58**
Sex of calf	1.70	2.59
Body condition score	11.10**	13.47**
Calf birth date	3.48*	4.37*
Sire birth weight	4.00*	3.69*
Pelvic area	1.93	0.03
Hip height	4.67*	1.97
Weight	2.05	3.07*
Total variation explained	26.62	28.44

[a] After breeding: heifer's traits measured two months after breeding; Before calving; heifer's traits measured two months before calving.

* $p < 0.05$.

** $p < 0.01$.

Breed group, heifer's body condition score, birth weight of calf's sire, calf birth weight and the ratio of calf birth weight to pelvic area had significant effects on calving performance in all respective models used for analyzing the data. Calf birth date had a significant effect on calving performance when heifer's traits were measured before calving (Models II, IV and VI). However, when heifer's traits were measured after breeding (Models I, III and V), it was significant only from analysis of Model V. The only significant effect of heifer's weight on calving performance was from analysis of Model VI when heifer's traits were measured before calving. The ratio of horizontal pelvic diameter to hip height had a significant effect on calving performance when the heifer's traits were measured before calving (Model IV). The effect of hip height was significant only from analysis of Model V (table 3) when heifer's traits were measured after breeding. These results indicate that weight and hip height of heifers themselves may not be important factors in the present data.

Calf birth weight was a important variable affecting calving difficulty ($p<0.01$), explaining over 12% of the total variation in calving difficulty score. The important contribution of calf birth weight to the variation in calving difficulty score (table 3) is in agreement with other reports (Morrison et al., 1985; Johnson et al., 1988; Naazie et al., 1989; Van Donkersgoed et al., 1990). Pelvic area itself did not have a significant influence on calving difficulty score. However, the ratio of calf birth weight to pelvic area which can be considered as a measure of feto-pelvic incompatibility accounted for even more variation (> 13%) in calving difficulty score than calf birth weight (table 3). The large impact of the ratio of calf birth weight to pelvic area on calving difficulty score in this study is in agreement with other studies (Bellows et al., 1971; Rice and Wiltbank, 1972).

In the comparisons of calving difficulty among condition score groups and between breed groups (table 4), the least squres means obtained from analyses of Models I and II are presented. However, other models provided similar results. Body condition score accounted for over 11% of the variation in calving difficulty when calf birth weight was excluded from the model (Model V and VI, table 3), which is in agreement with the results of other studies (Makarechian and Berg 1983; Naazie et al., 1989). The maximum least squares means of calving difficulty score of heifers were with body condition scores of

1 and 4 (extremely thin and fat). Heifers with a body condition score of 3 had the lowest calving difficulty score (table 4). The low incidence of calving difficulty among heifers with body condition score of 3 indicates the importance of optimum condition for the process of parturition. The SY#1 heifers had a higher level of calving difficulty compared to the DS heifers ($p < 0.05$, table 4).

In addition, the heifers delivering in the early spring tended to have more calving difficulties compared with those delivering later as the partial regression coefficient of calving difficulty score on calving date was negative ($p < 0.05$). This may be a result of a longer period of feed supplementation which had greater effect on improving the body condition of heifers calving later in the season (Makarechian and Berg, 1983).

TABLE 4. LEAST SQUARES MEANS OF SNELL TRANSFORMED CALVING SCORE BY BREED GROUPS, AND BODY CONDITION SCORE OF HEIFERS

Item	Snell calving scores ± Std. Error*	
	Model I	Model II
Breed groups:		
Beef synthetic	42.01 ± 8.11[a]	42.36 ± 7.88[a]
Dairy synthetic	23.89 ± 7.65[b]	24.76 ± 7.57[b]
Body condition scores:		
1	48.01 ± 13.16[c]	48.37 ± 12.97[c]
2	22.57 ± 4.25[cde]	23.48 ± 4.19[cde]
3	11.88 ± 5.51[e]	10.40 ± 5.41[e]
4	49.35 ± 23.03[cd]	51.98 ± 22.72[cd]

* LSMEANS from PROC GLM in Model I and Model II.
Score: 1 = extremely thin, 2 = thin; 3 = moderate; 4 = fat.
Snell calving score: 0 = normal delivery to 100 = Puller used, easy or hard.
[a,b,c,d,e] Means within a column and subclass bearing different letters are significantly different ($p < 0.05$).

The results of this study indicate that the incidence and severity of calving difficulty in first calving heifers could be significantly reduced by the following strategy: 1) Selecting bulls with low birth weight on heifers to reduce calf's birth weight, 2) Selecting heifers with relatively well developed pelvic opening relative to expected calf birth weight, and 3) Keeping heifers in optimum body condition (score of 3) during pregnancy.

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