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Factors associated with calving difficulty in embryo transfer mated cattle

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ABSTRACT

Data were collected from 249 cows over 2 years at Whatawhata Research Centre on pelvic area, weight and breed of embryo transfer mated cow, calf birth weight, breed and a defined calving difficulty score. Cow liveweight and pelvic area were significantly correlated (R^2 = 0.56, P< 0.05), but cow liveweight and calf birth weight were not (R^2 = 0.07, NS). Cow pelvic area and calf birth weight were also not related (R^2 = 0.04, NS). In July of each year, the Jersey cows were 119 kg lighter (P<0.001), had a smaller pelvic area (264 vs. 322 cm^2, P<0.001) and more calving difficulties (26 vs. 5%, P<0.001) than Hereford x Friesian (HxF) cows. Across breeds, pelvic area (P<0.01) and cow liveweight (P<0.001), when fitted individually, were negatively associated with the probability of a cow having an assisted calving. On its own, the impact of calf birth weight was NS, although it explained additional variation (P<0.05) if cow liveweight was in the model. Within the range of calf breeds (NS) we used, we predict that any of recipient breed, cow liveweight or pelvic area (in decreasing order of reliability) could be used to reject cows at ET that might cause problems at calving although errors of estimation will result in wasteful rejection of cows and will not eliminate calving problems.

Keywords: embryo transfer; cows, calving difficulty, birth weight, live weight, pelvic area.

INTRODUCTION

Embryo transfer (ET) in cattle offers the opportunity to separate the genetics of the calf from those of the cow (Thompson *et al.*, 1998). Small, high milk-producing cows such as Jerseys could be ET mated to high growth rate calf breeds thereby offering a quantum leap in feed conversion efficiency. However, the most obvious risk of doing this is calving difficulty. Selection of low risk recipient cows prior to ET would be advantageous. Overseas research (Basarab *et al.*, 1993; Short *et al.*, 1979; Wolverton *et al.*, 1991) has indicated that pelvic dimension can be a useful predictor of calving difficulty. It was found to be 50% accurate in identifying parturient heifers that require caesarean section (Wolverton *et al.*, 1991). A combination of calf birth weight and pre-calving pelvic area accounted for 45% of the variation in calving difficulty scores. Calf birth weight accounted for about 33% of the variation and cow pelvic area accounting for 12% (Johnson *et al.*, 1988).

A major cause of calf deaths at calving is due to slow or difficult births (Morris, 1994). Measurements of pelvic area have been used in the selection of heifers for breeding programmes, identifying those heifers with a high risk of dystocia. The ratio of calf birth weight to pelvic area or fetal-pelvic incompatibility (FPI) was shown to be an important determinant of dystocia in heifers (Morris 1994; Naazie *et al.*, 1989; Wolverton *et al.*, 1991). Ratios of heifer pelvic area to body weight have been used to select heifers that have more pelvic area per kg of body weight. In the short term this can reportedly reduce calving difficulties by 10% (Basarab *et al.*, 1993). The technique of pelvimetry is reported to be safe with repeatability of measurement in the range of 0.87 to 0.95 (Wolverton *et al.*, 1991; Short *et al.*, 1979).

Outstanding features of the above research were that (1) the results were mostly obtained from heifers and (2) the cows and their calves were genetically related. The following work describes calving results from *mixed-age* cows, which had been mated by ET so that the cow and calf were not genetically related. Heifers were excluded from the project to reduce the risk of dystocia. The ET mating, pregnancy rates, embryo survival, cow and calf survival at calving, calf growth rates, cow plus calf intakes through lactation have been reported elsewhere by Smeaton *et al.* (2003) and Smeaton *et al.* (2004). This project was part of that experiment. We report here on the factors affecting calving difficulty and their value for predicting calving difficulty with a view to rejecting high-risk cows at ET mating. The results were obtained from a range of recipient breeds carrying a range of calf breeds over 2 years of calving.

TABLE 1: Numbers of recipient cows, and calves born, both years combined, by breed.

Recipient Breed	Embryo breed			
	HxF	SxF	Waygu	Total
Friesian, FxJ	7	8	6	21
HxF	104	29	15	148
Jersey	58	0	22	80
Total	169	37	43	249

TABLE 2: Effect of breed on various parameters. Calving results for the 2001 and 2002 years were combined for the analyses. Caving problem probability indicates the chance of having a calving problem described by any of scores 1, 2 or 3.

Parameter	Jersey	HxF	Signif.	SED
Cow liveweight at weaning (kg)	375	528	***	7
July cow liveweight (kg)*	380	499	***	7
Calf birth weight (kg)	33.9	36.3	***	0.8
Pelvic area (cm^2)	264	322	***	4.3
Calving problem (probability.)	0.26	0.05	***	0.08
Count cows calving score 0	42	139	N.A.	
Count cows calving score 1	19	1	N.A.	
Count cows calving score 2	8	8	N.A.	
Count cows calving score 3	6	0	N.A.	

* 6 weeks prior to calving
N.A. No analyses carried out on these scores

MATERIALS AND METHODS

Table 1 describes the numbers and breeds of cows and calves involved in the project in each of the calving years 2001 and 2002. Approximately 800 cows were submitted for ET mating. Cows found not to be pregnant to ET left the project after pregnancy testing.

Internal pelvic measurements were carried out on the cows at ET mating and on all pregnant cows in the third trimester of pregnancy using the Rice pelvimeter inserted in the rectum as described by Wolverton *et al.* (1991). A width measurement was taken at the widest point, between the shafts of the ileum, and a height measurement was taken between the floor of the pelvis and the sacrum. The width times the height gave an estimate of pelvic area (cm^2). All calves were weighed at birth and approximately monthly thereafter through to weaning. Calving difficulty was also assessed on a scale of 0 to 3 where:

0 = no assistance required
1 = cow assisted in the paddock
2 = cow assisted in the yards
3 = caesarean section required

The lowest level of assistance was always applied first. If this failed to result in delivery of the calf, the next level of assistance was then applied. Cow and calf survival, birth date, gestation length (from date of synchronised ovulation) were recorded. Some of the cows were part of a managed calving programme (Lambert *et al.*, 1998) to reduce gestation length by approximately 7 days. This was carried out for animal ethics reasons to keep control of calf birth weight after problems experienced in the first year (not described here because pelvic data were not recorded). The cows were weighed at calving and otherwise on an approximately monthly basis. Other details of overall project design and measurements taken were described by Smeaton *et al.* (2003) and Smeaton *et al.* (2004).

Statistical analyses were carried out on the data using analysis of variance (Genstat Committee, 2002). All data presented are fitted estimates. First-order interactions were tested but were never significant and so were omitted from the final models. When analysing calving difficulty, the calving codes described above were combined into 0 = 'no problem' and 1 = 'problem'. This was done because there was too little data in the separate categories of calving difficulty (Table 2). The fitted prediction lines in Figures 1 and 2 were derived using a mixed model smoothing programme (Upsdell, 1994).

RESULTS

Breed Effects

There were pronounced breed effects on all the parameters shown in Table 2. The HxF cows were 31% and 40% heavier than the Jerseys 6 weeks before calving and at subsequent weaning, respectively. However, the HxF cows had calves whose birth weights were only 7% heavier than those from the Jersey cows. The Jersey cows had a 22% smaller pelvic area than the HxF and a quarter of the Jersey cows had a calving problem of some description compared to virtually no problems (5%) in the HxF.

Prediction functions for calving problems

The probability of calving problems (in the absence of recipient cow breed) showed significant dependence on either pelvic area ($P<0.01$, Figure 1) or July cow liveweight ($P<0.001$, Figure 2). In addition, an earlier (May) cow liveweight was just as good a predictor of calving problems ($P<0.001$), as was July cow liveweight. The two cow liveweights were highly correlated (R^2 = 0.95). Cow liveweight and pelvic area each explained 8 and 5 % respectively of the total variation in calving problem.

FIGURE 1: The predicted probability of calving problems, dependent on pelvic area, across recipient cow breeds.

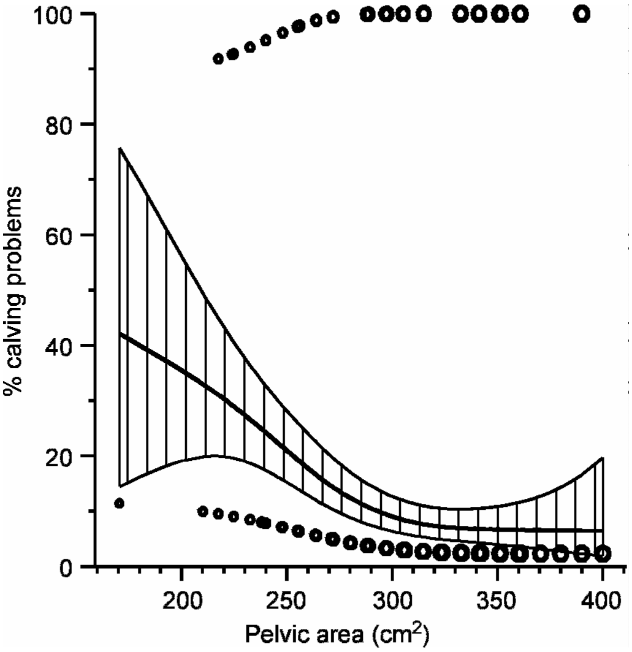
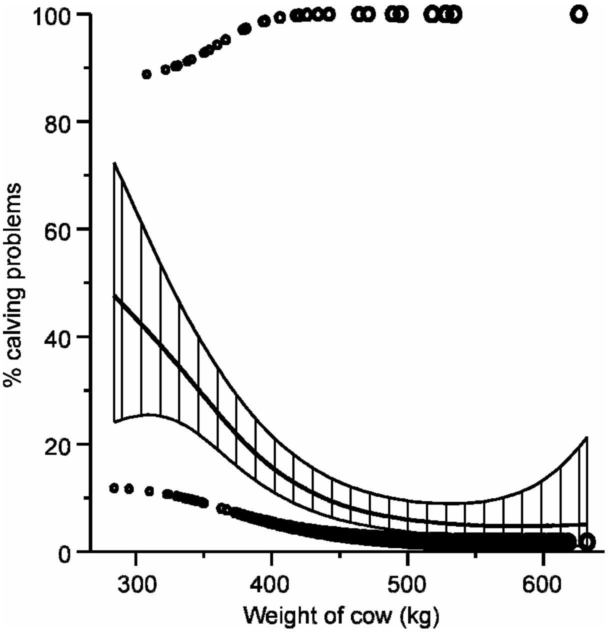


FIGURE 2: The probability of calving problems, dependent on July cow liveweight, across recipient cow breeds.



Pelvic size and cow liveweight, in either May or July, were significantly correlated (R^2 = 0.72 to 0.74, Figure 3). Therefore, if July cow liveweight was present in the model, adding pelvic area explained no further variation in calving problems. Pelvic area in July was correlated with pelvic area in August (R^2 = 0.54, P<0.01).

Calf birth weight (across calf breeds) was not significantly related to calving problem and it was not related to either pelvic area (R^2 = 0.04, N.S.) or July cow liveweight (R^2 = 0.08, N.S., Figure 4). Birth weight effects on calving problem were only significant (P<0.05) if cow breed was present in the model. Although our data indicated more problems were occurring with heavy calves from low liveweight cows or in cows with smaller pelvic areas, analysis of these interactions showed them to be non-significant. Our data also demonstrated that big cows or cows with large pelvic areas had few calving problems but again, this effect was non-significant.

FIGURE 3: The relationship between July cow liveweight and pelvic area, across recipient cow breeds

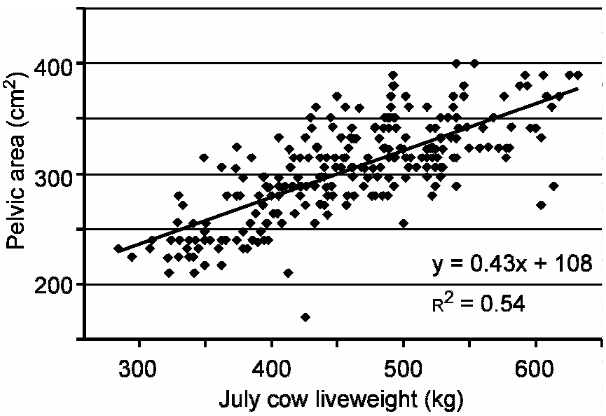
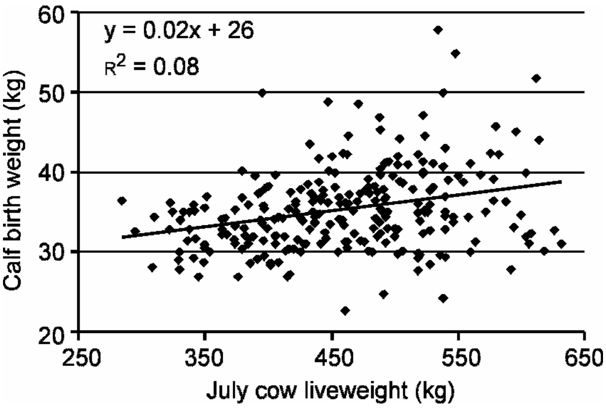


FIGURE 4: The relationship between July cow liveweight and calf birth weight across recipient cow, and also calf breed.



In summary, calving problems were explained by any of cow breed, cow liveweight, pelvic area with each explaining 8, 8 and 5% of the variation respectively.

DISCUSSION

The recipient breed effects on cow weaning weight were as reported by Smeaton *et al.* (2004). The breed difference prior to calving of 119kg was inconsistent with and less than the expected 150kg difference observed at other times of the year (Smeaton *et al.*, 2004). A possible explanation for a small part of the difference may be that the two recipient breeds were carrying similar embryo breeds, which were therefore relatively heavier in the Jersey than in the HxF cows.

Recipient breed affected calf birth weight by 10% even though there was no genetic link between dam and calf. This effect may have reflected the impact of maternal nutrient supply to the foetus by the smaller vs.

larger cow. Our calves were also 1 to 2 kg heavier than had been expected from calves of similar breed elsewhere (Baker *et al.*, 1990) although these same authors noted that environment affected calf birth weight by up to 2.7kg between their best and worst farming sites. Alternatively, our calves may have been 1 to 2kg heavier than those of Baker *et al.* (1990) due to the ET-IVP procedure (Thompson and Peterson, 2000).

The absence of a significant relationship between July cow liveweight and calf birth weight would have been an unusual result where cow and calf were genetically linked via existing reproduction methods (Anon, 2000). However, it is likely to be a common result for ET matings, especially where cow and calf genetics are intentionally made widely different.

Given the above, it should therefore not be surprising that if cow liveweight were a significant predictor of calving problem in our data, calf birth weight would not be. However, it *was* surprising that calf birth weight was such a poor predictor given the support it has received in the literature (Cummins, 1984; Johnson *et al.*, 1988; Bellows *et al.*, 1991; Kilkenny and Stollard, 1976; Naazie *et al.*, 1989; Short *et al.*, 1979; Wolverton *et al.*, 1991). In addition, Short *et al.,* (1979) and Bellows *et al.,* (1991) considered cow liveweight to be unimportant relative to calf birth weight.

The relationships we established between cow liveweight and pelvic area, and pelvic area and calving problems were in agreement with other reported results (Basarab *et al.*, 1993; Cummins, 1984; Johnson *et al.*, 1988; Morris, 1994; Bellows *et al.*, 1991; Short *et al.*, 1979; Wolverton *et al.*, 1991).

The important question from a practical perspective is how can we accurately predict calving problems and therefore reject susceptible cows, before they enter the ET mating programme? Unfortunately, the literature cited above referred almost exclusively to research done on first-calving heifers, the age class where most calving problems occur in normally mated herds. Heifers were rejected from this project to minimise the risk of calving problems which occurred anyway. In addition, Basarab *et al.* (1993), Laster (1974), Morris (1994), Naazie *et al.* (1989), Van Donkersgoed *et al.* (1993), and Wolverton *et al.* (1991) all came to a similar general conclusion that pelvic area, birth weight and/or foetal-pelvic disproportion and cow weight, while significantly linked to calving problems, were not of much practical use. This was due to prediction errors in estimating calving problems with the result of higher than acceptable culling rates, or in our case, rejection at ET mating. We concur with this general conclusion. Our predictors explained far too little variation in calving problems to be of any real practical value. In addition, Van Donkersgoed *et al.* (1993) observed that repeatability of pelvic area measurements between and within veterinarians were only low to moderate and they could not recommend the use of pelvimetry.

CONCLUSIONS

Our results showed that cow liveweight, pelvic area and breed were all significant predictors of calving problems but individually they only accounted for 5 to 8% of the total variation. This severely compromised their value as predictors of calving problems. Other approaches to minimising the risk of calving problems should be sought. We attempted or tested three of these: (1) managed calving, (2) choice of sire of embryo breed and (3) selection of recipient breed. Smeaton *et al.* (2004) reported that managed calving was not a particularly successful approach as they were concerned that it could compromise the immune system of the dam. It also will add cost. We demonstrated that choice of recipient breed can reduce calving problems (5% in the HxF) to low levels (Baker *et al.,* 1990) vs. the unacceptably high level of 26% in the Jersey in our data. However, this would then destroy the feed-conversion-efficiency gains deemed possible by Smeaton (2001) and Smeaton *et al.* (2004) in using a small recipient cow with a fast growth rate calf.

The best solution, in our opinion, lies with two possibilities: (1) Use a niche market embryo where the niche returns outweigh any concerns about feed-conversion-efficiency so that the optimum cow breed can be used for low calving problems or (2) Use a low birth weight, high liveweight-gain embryo sire. We attempted this in our project but our results demonstrated that we were less than totally successful. This is because this kind of bull, at present, is hard to come by due to the high correlation between birth weight and liveweight gain (Anon, 2000). Nevertheless, a search for this rare animal would be very worthwhile.

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