SURVIVAL OF CROSSBRED CALVES: EFFECT OF CALF SIZE AT BIRTH

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SUMMARY

Survival at birth depends on size at birth in a quadratic manner. Inclusion of the quadratic terms of the covariates girth, weight, height and length at birth in the model fitted to survival at birth increased the explained variation (R^2) from 17.6% to 21.0%. Girth was the most important of these measures of size at birth. Use of girth and girth squared instead of birth weight and birth weight squared increased the R^2 from 16.0% to 19.7%. The phenotypic correlations between weaning weight and birth weight or birth weight squared were 0.42 and between weaning weight and girth or girth squared were 0.29. These associations suggest that girth and girth squared may be better selection criteria than birth weight and birth weight squared for programs attempting to genetically improve both calf survival and growth rate.
Keywords: Cattle, survival, birth weight, girth, models

INTRODUCTION

Calf deaths at birth represent a significant loss to the beef industry. Studies have demonstrated a highly significant quadratic relationship between birth weight and calf survival at birth (Koger et al. 1967, Meijering 1984, Morris et al. 1986). Gardiner and Rutley (1995) suggested using this relationship in selection indices to reduce calf loss by optimising size at birth.

Calf dimensions at birth do not affect calf survival when birth weight is held constant (Meijering 1984, Nugent and Notter 1991). However, there is no mention in these reports of the use of quadratic relationships. In this paper we examine the effect of quadratic relationships of calf weight, height at the hip, length and girth at birth on calf survival.

MATERIALS AND METHODS

Records from 3 calf drops sired by Angus, Belgian Blue, Hereford, Jersey, Limousin, South Devon and Wagyu bulls, born to Hereford cows in the 'Southern Crossbreeding Project' (Rutley et al. 1995) were used. Weight, height at the hip, length (from the spinous process of the first thoracic vertebra to the anus), and girth (immediately posterior to the shoulders), were recorded at birth for calves born in 1994 - 96. Weight at weaning (300 days) was also recorded for calves born in 1994 and 1995. Twins were removed from the data leaving 1039 calves born to 74 sires with records from birth. Of the 1039 calves, 60 (5.8%) did not survive birth. Survival at birth was defined as survival to 7 days post-partum and recorded as a binomial trait. Records from weaning of 723 calves born over 2 years to 52 sires were used.

Data were analysed using Restricted Maximum Likelihood in Proc Mixed (SAS Institute Inc. 1992). Different models were compared using type III estimable functions. Three models were used to examine the effects of different measures of size at birth on calf survival at birth.

model 1 aim: to explain survival at birth.
fixed effects: sex, management group, year, age of dam and calf breed.
random effects: sire nested within both year and calf breed.
covariates: birth day, birth weight, height, length and girth.

model 2 as for model 1 with both linear and quadratic terms of the size covariates.

model 3 aim: to examine genetic and phenotypic correlations.
fixed effects: sex, management group, year, age of dam and calf breed.
random effects: sire nested within both year and calf breed.
covariate: birth day.

RESULTS

Summary statistics of the data are presented in Table 1. The amount of variation explained (R^2) by different models fitted to survival at birth is presented in Table 2. When only linear functions of size at birth measurements were included as covariates (model 1), 17.6% of the variation in survival at birth was explained. In this analysis height at birth was the most significant covariate followed by weight, then length. The slope of girth was not significantly different from zero. Inclusion of the squared terms of the size covariates (model 2) improved the R^2 value from 17.6% to 21.0%. Girth and girth squared became highly significant ($P<0.001$) in the model whereas other size covariates became non-significant.

Table 1. Summary statistics for measurements of size at birth

Trait	Mean	Standard deviation	Minimum	Maximum
Birth weight (kg)	38	7	15	61
Height (cm)	75	5	44	89
Length (cm)	60	5	41	94
Girth (cm)	73	5	40	97
Weaning weight (kg)	279	45	146	423

Model 2, containing only the covariates birth weight and birth weight squared, explained 16.0% of the variation in survival at birth. When these two covariates were substituted for girth and girth squared the R^2 value increased to 19.7%.

Phenotypic correlations between survival and measurements of size at birth and weight at weaning are presented in Table 3. The phenotypic correlations between the linear and quadratic terms of each size trait approached 1.00. Only the genetic correlations between survival and girth (-0.68 ± 0.24), girth squared (-0.78 ± 0.18) and birth weight squared (-0.82 ± 0.15) were significantly different from zero. No other measures of size at birth had a significant ($P<0.05$) genetic or phenotypic correlation with survival at birth.

Table 2. Explanation of variation in survival at birth

Model	Covariate	Denominator degrees of freedom	Regression coefficients	R^2 (%)	
				Individual or paired covariates	All covariates
Model 1	weight	907	-0.0047*	15.3	
	height	907	0.0051**	16.5	
	length	907	-0.0032*	16.4	
	girth	907	0.0031	16.3	17.6
Model 2	weight	903	0.0028		
	weight squared	903	-0.0001	16.0	
	height	903	-0.0213		
	height squared	903	0.0002	17.5	
	length	903	-0.0089	*	
	length squared	903	0.0000	16.7	
	girth	903	0.1099***		
	girth squared	903	-0.0007***	19.7	21.0

* $P<0.05$; ** $P<0.01$; *** $P<0.001$.

Table 3. Phenotypic correlations between survival and measurements of size at birth and weight at weaning

Trait	Birth weight	Height	Length	Girth	Weaning weight
Survival at birth	-0.04 (-0.05)	0.06 (0.05)	-0.06 (-0.06)	0.04 (0.02)	-
Birth weight	-	0.06	0.39	0.59	0.42
Weaning weight	-	0.31	0.22	0.29	-

Correlations in () are between survival and the size trait squared.

DISCUSSION

Use of squared measures of size at birth increases the explained variation in survival at birth from 17.6% (model 1) to 21.0% (model 2). This supports the argument for using a squared term as a restriction to increase beef production through improving survival at birth (Gardiner and Rutley 1995). Removal of non-significant size-at-birth covariates left girth and girth squared as the only size covariates in the model. This model had an R^2 value of 19.7%.

The comparison of model 2, containing only birth weight covariates, to model 2, containing only girth covariates, suggests that girth is a superior covariate for explaining variation in survival at birth. This suggestion is supported by the lower phenotypic correlations between girth and weaning weight than between birth weight and weaning weight. However, from the point of view of genetic improvement, true economic improvement depends on the phenotypic and genetic correlations between the indicators of size at birth and all economically important traits and relevant selection criteria. The phenotypic and genetic correlations between girth, girth squared, birth weight squared and important economic traits and relevant selection criteria still need to be estimated (Koots et al. 1994). At this stage these genetic correlations cannot be accurately estimated from our data set. Expected lower genetic correlations between girth and girth squared and weight at later ages than those between birth weight and birth weight squared and weight at later ages would be a potential advantage for the use of girth and girth squared as selection criteria.

These findings suggest that both girth and girth squared at birth are good candidate criteria to use in a selection index to improve calf survival at birth. Kempthorne and Nordskog (1959) suggested and Goddard (1983) acknowledged that a quadratic relationship could be used to maximise production by optimising traits that are associated with fitness or survival. This would be appropriate where traits are presently close to some biological optimum and movement away from that optimum, through correlated response to selection, would reduce production. Other reasons adding to the attractiveness of girth and girth squared at birth as selection criteria are their ease and cost of measurement.

CONCLUSION

The variation explained by different models supports the findings of other researchers that a quadratic relationship exists between measurements of size at birth and survival at birth. Our study shows that this relationship exists for measures of size other than birth weight, namely girth, height and length at birth. This study further suggests that girth and girth squared may be superior to birth weight as criteria to prevent calf losses at birth while selecting for increased weight at later ages.

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