LONGEVITY AND LIFETIME PRODUCTIVITY OF F_1 COWS FROM SEVEN BEEF BREEDS

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INTRODUCTION

The ability of a breeding female to reproduce over a long period of time is an important aspect in increasing the efficiency of livestock production because maintenance costs, until culling or death, will be less due to proration of costs before first mating over the larger number of progeny weaned.

Data on longevity of reproduction in beef cattle is sparse. Cundiff et al. (1985) and Nuñez et al. (1985) reported moderate amounts of heterosis for longevity (16%), survival (16%) and cumulative production of 200 day weaning weight per female (30%). Tanida and Hohenboken (1988) reported heritabilities between .16 and .18 for length of life, age at disposal and number of calves weaned, with genetic correlations between .90 and 1.

Although fully measured too late in life to be of practical use in selection criteria for the animals being tested, evaluation of lifetime productivity should be an important step in the formulation of breeding objectives (Newman et al., 1985) and the implementation of breeding programs (Harris et al., 1984).

Accordingly, the objectives of the present study were (1) To study F_1 females of diverse biological type for differences in longevity; (2) To identify early-in-life indicators of longevity; (3) To identify early-in-life indicators of total lifetime productivity, defined as the average (age and sex adjusted) weight of calf weaned per breeding female.

MATERIALS AND METHODS

In 1974, F_1 heifers were derived from mating: Hereford dams to Brahman (F_1=21), Sahiwal (11), Charolais (17) or Simmental (17) bulls; Friesian (20) or Shorthorn (20) dams to Hereford sires; Hereford dams to Jersey sires and reciprocals (20). The F_1 females were crossed with Hereford sires to produce backcross calves during the years 1976 to 1984. The breeds utilized represented zebu, European, dairy and British types. The experiment took place at the Wanbi Research Centre, about 160 km northeast of Adelaide. Mean rainfall is 281mm and there are 5 months effective rainfall per year. Pastures consist of native herbs, *Kochia* spp., subterranean clover, medics, perennial veldt grass, barley and oat stubbles and lucerne. Cows were grazed at a stocking rate of 1 cow per 10 ha in 50 ha paddocks.

Longevity

Analysis of survival indicates that we are interested in the study of mortality, where the data arise from recording times of death ("failure") of individuals. During the course of the study, some of the individuals did not fail and their failure times are known only to be beyond the end of the study. Such data are said to be *censored*. Table 1 presents information from the seven breed groups on number of deaths (failures) and number of censorings. Note that censoring occurred due to (1)the culling policy of the experiment, i.e., culling a cow if she failed to produce a calf in two consecutive years; and (2) the experiment ending prior to the death of all cows.

Table 1. Distribution of failures and censoring.

		Censored observations	
	Failures (death)	Still alive	Culled (infertility)
Brahman	7	10	4
Sahiwal	3	8	0
Charolais	1	10	6
Simmental	8	8	1
Friesian	6	10	4
Jersey	4	12	4
Shorthorn	9	7	4
Totals	38 (30%)	65 (52%)	23 (18%)

In longevity studies, it may be desirable to assess the relationship between mortality and other measures made early or late in life. In the present context, our measure of mortality is the age (in years) of the cow when she was removed from the herd, or at termination of reproduction (AGE). The explanatory variables we considered are those measured early in life, with the aim of identifying possible early-in-life indicators of longevity. The variables considered were (1) Puberty weight (PWT); (2) Puberty age (PAG); (3) Age at first calf (AFC); (4) Weaning weight of first calf (WFC); and (5) Weight of cow at weaning of first calf (WCW).

An accelerated failure-time model has been used. Its general form is $\mathbf{y} = \mathbf{X}\beta + \sigma\varepsilon$, where $\mathbf{y}$ is a vector of the logs of AGE, $\mathbf{X}$ is a matrix of covariates or explanatory variables, β is a vector of unknown regression coefficients, σ is a scale parameter and ε is a vector of errors from an assumed distribution. The model is so named because the effect of the covariates is to scale a baseline distribution of failure times (Cox and Oakes, 1980). PROC LIFEREG (SAS, 1985) was used to fit a Weibull distribution to the data.

Lifetime productivity

Lifetime productivity was defined in the present study as the ratio of age and sex adjusted weaning weight to number of calves weaned per cow, i.e., the mean weight of calves weaned for each cow (AWT). Residual correlations (breed adjusted) between AWT and the five traits mentioned previously are presented in table 2. An all-subsets regression procedure (BMDP, 1985) was utilized to derive standardized partial regression coefficients of AWT on the five explanatory variables to study the influence of each early-in-life trait on lifetime productivity.

Table 2. Residual correlations.

	PAG	AFC	WFC	WCW	AWT
PWT	.30**	.05	.16	.55**	.35**
PAG	1.0	.27**	.23**	.13	.01
AFC		1.0	.44**	.43**	-.24**
WFC			1.0	.29**	.39**
WCW				1.0	.17

RESULTS AND DISCUSSION

Longevity

Because of small sample sizes within some of the cells in table 1, the data were reclassified according to biological type (zebu, European, dairy, British) before fitting the accelerated failure-time model. The results are presented in table 3.

Table 3. Results of survival analysis.

Group	Age	Intercept	Scale	Survival (10 yr)	Number remaining
Zebu	10.4	3.1±.4	.11±.03	.7421	18/32
European	9.6	1.5±.7	.18±.05	.7313	17/34
Dairy	10.6	-3.3±6	1.00±.00	.6954	4/40
British	10.1	4.8±1	.14±.04	.5208	7/20

There was little difference in mean age at termination for any of the groups. The intercept values were all significantly different from zero, except for the intercept value for the dairy group. In terms of the original event times the effects of the intercept and the scale term are to scale the event time and power the event time, respectively. The column labeled "Survival (10 yr)" contains the probability of survival until age at least 10 years. Zebu-cross cows expressed the greatest survival rate at 10 years of age, followed by European, dairy and British. Number remaining signifies the number of censored observations remaining after the last death was recorded. The negative value for the intercept for dairy could have been due to there being only four out of 40 individuals remaining after the last death.

The effect of the five explanatory variables on longevity was inconclusive. Both AFC and WCW were important ($P<.01$) contributors to variability in the European-cross cows. All other chi-square probabilities for combinations of group and covariate ranged from .09 to .95.

Lifetime productivity

The results of the analysis of AWT with the five early-in-life indicators are presented in table 4. Each line of the table represents the model derived for each additional trait, along with the corresponding R^2 (multiple coefficient of determination) resulting from the combined association of all variables included. The variable added at each step is the one which results in the greatest increase in R^2. The last line of the table, labelled "contribution" is the amount by which R^2 would be reduced if the variable heading the column were removed from the regression equation. The contribution is presented only for the last model with the largest R^2.

Table 4. Standard partial regression coefficients of AWT on WFC, AFC, PWT, PAG, WCW.

Added trait	R^2	WFC	AFC	PWT	PAG	WCW
WFC	.11	.327**				
AFC	.22	.583**	-.422**			
PWT	.23	.562**	-.423**	.122		
PAG	.24	.563**	-.433**	.111	.104	
WCW	.25	.541**	-.468**	.078	.111	.102
Contribution		.173	.123	.005	.012	.006

All partial regression coefficients were positive except for AFC. AFC expressed a negative correlation of -.24 with AWT. Standard partial regression coefficients for PWT, PAG and WCW were not different from zero ($P>.05$). Note from table 2 that the correlations of AWT with PAG and WCW were not different from zero as well. The combination of WFC and AFC accounted for the largest portion of R^2. Indeed, the addition of AFC to the model doubled the coefficient of determination. Increases in R^2 were negligible after this point.

It was the intention of this study to attempt to identify early-in-life indicators of longevity and lifetime productivity in beef cattle. The results proved very inconclusive. Ideally, any longevity study should last until all animals die from natural causes; only then can proper estimates of survival be obtained. It was not the intention of the present study to measure survival, but it seemed worthwhile to consider. Furthermore, the sample sizes within breed group were small, which could cause large sampling errors in the estimation procedure. This may also have affected the sensitivity of the explanatory variables to gauge changes in longevity.

The results of the lifetime productivity study were possibly somewhat more revealing. We found that the combination of two early-in-life traits, weaning weight of first calf (WFC) and age of cow at birth of her first calf (AFC) accounted for the greatest amount of variability in average weaning weight (AWT).

REFERENCES

BMDP STATISTICAL SOFTWARE (1985 edition).

CUNDIFF, L.V., NUÑEZ, R.D., DICKERSON, G.E. and GREGORY, K.E. (1985). Proc. Midwestern Section, Amer. Soc. Anim. Sci. p.75 (abstr.).

COX, D.R. and OAKES, D. (1980). "Analysis of Survival Data" Chapman and Hall, London.

HARRIS, D.L., STEWART, T.S. and ARBOLEDA, C.R. (1984). "Animal Breeding Programs: A Systematic Approach to Their Design" USDA-ARS, Peoria, Illinois.

NEWMAN, S., HARRIS,D.L. and DOOLITTLE, D.P. (1985). J. Anim. Sci. 60:385.

NUÑEZ, R.D., CUNDIFF, L.V., DICKERSON, G.E. and GREGORY, K.E. (1984). J. Anim. Sci. 59:180 (abstr.).

SAS USERS GUIDE: STATISTICS (1985).

TANIDA, H., HOHENBOKEN, W.D. and DeNISE, S.K. (1988). J. Anim. Sci. 66:640.