MATURE COW SIZE AND ITS RELATIONSHIP TO LIFETIME PRODUCTIVITY

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INTRODUCTION

Profitability of beef cattle production is dependent upon a myriad of economic, environmental and biological factors. Maximising profitability can be achieved in different ways. For example, one could decrease expenses through the use of animals that more efficiently convert feed to lean mass or approach market weights at earlier ages. Alternatively, increased reproductive rate can decrease parental costs relative to a larger number of young and thus increase income through greater live weight marketed over a breeding female's lifetime. Although measured too late in life to be of practical use as selection criteria for the animals being tested, evaluation of lifetime productivity should be an important step in the formulation of breeding objectives and the implementation of breeding programs.

Some studies in the animal breeding literature have demonstrated that larger cows produce calves with heavier weaning weights but the number of calves produced per cow bred, or in a cow's lifetime tended to decrease with increasing mature size (e.g. Stewart and Martin 1983). Therefore the objective of the present research was to study differences between F_1 cows for mature cow size and its relationship to lifetime productivity.

MATERIALS AND METHODS

Seven breeds of cattle were mated to produce F_1 heifers during the year 1974. A total of 126 heifers were entered into the study. Hereford bulls were mated to Shorthorn (20 heifers) and Friesian (20) cows, Sahiwal (11), Charolais (17), Simmental (17) and Brahman (21) bulls were mated to Hereford cows, and reciprocal crosses involving Jersey (20) and Hereford. These breed groups represent diverse biological types of zebu, European, dairy and British breeds. All females were mated to Hereford bulls each year to produce backcross calves. Cattle were grazed in a semi-arid environment at Wanbi, South Australia. First calvings occurred in 1976 and final calvings in 1984. Details of experimental design, cattle management, reproductive performance and postweaning growth and carcass composition are given by Deland and Newman (1989) and Newman and Deland (1989).

Mean ages at first calving for the breed groups were Brahman (2.45 years), Sahiwal (2.26), Friesian (2.02), Jersey (2.18), Charolais (2.10), Simmental (2.23) and Shorthorn (2.18).

Deland and Newman (1989) reported important breed group and date of puberty differences on age at first calving from heifers in the present study.

Heifers were weighed every seven weeks (except during calving) from an average age of 250 days until removal from the herd. Records on 112 cows were used in the estimation and analysis of mature cow size, using a non-linear regression equation described by Brody (1945): $Wt(t) = A - Be^{-kt}$, where $Wt(t)$ is weight at time t, A is the asymptotic (mature) weight, B is an integration constant, e is Napier's base for natural logarithms, k is the maturation rate parameter and t is age in days. Because birth weights on all heifers were not available, estimates of k were not considered reliable and will therefore not be presented.

The following measures of lifetime productivity were calculated for each cow: (1) number of years in the herd (AT); (2) number of calves weaned (NW); (3) cumulative (total) weaning weight produced (CWWT); (4) average weaning weight per calf weaned - the ratio of cumulative weaning weight to number weaned (AWWT); (5) average weaning weight per year in herd - the ratio of cumulative weaning weight to years in herd (AWWY); (6) total beef produced - the sum of cumulative weaning weight and mature cow size (TBP). All calf weaning weights were adjusted for the fixed effects of sex and parity (confounded with year and age of dam) before calculating CWWT, AWWT, AWWY and TBP.

The data were fitted to a model that contained breed group as a main effect and mature cow size (A) as a linear and quadratic covariate. Regressions were fitted within breed group. Optimal cow sizes were estimated as the partial derivative of the linear model $A_{opt} = \mu + \beta_1(A) + \beta_2(A)^2$, which yields an optimum at $\frac{\beta_1}{-2\beta_2}$ after setting the derivative with respect to A equal to zero.

RESULTS AND DISCUSSION

Breed group effects only differed for AWWT ($P<0.01$), AWWY ($P<0.05$) and A ($P<0.01$). The average number of years that cows stayed in the herd was 9.8 years. During that time, the average cow produced 7.2 calves which averaged 230 kg at weaning, for a total of 1635 kg of calf weight weaned in a cow's lifetime. Therefore, 168 kg of calf weight was weaned per year from cows which averaged 546 kg mature size. Breed group means are presented in Table 1.

Table 1 Least-squares means by breed group for characters related to lifetime productivity

Group	NW	AWWT	AWWY	CWWT	TBP	AT	A
Brahman	7.7±0.5	223.1±6.8	163.9±8.8	1653.8±121.9	2199.5±121.8	10.3±0.4	503.1±13.7
Sahiwal	7.7±1.1	226.4±13.7	176.8±17.8	1735.7±247.2	2281.4±247.1	9.8±0.8	508.0±17.5
Friesian	7.4±0.4	234.8±5.4	176.6±7.0	1747.0±97.6	2292.6±97.5	9.9±0.3	560.4±14.1
Jersey	5.6±1.5	238.8±19.0	141.5±24.7	1325.8±343.3	1871.4±343.1	9.3±1.1	460.2±13.7
Charolais	7.8±0.7	238.7±8.8	184.8±11.4	1853.4±158.5	2399.1±158.5	9.9±0.5	601.3±16.1
Simmental	7.0±0.6	244.3±7.6	178.7±9.8	1696.8±136.9	2242.5±136.8	9.3±0.4	595.6±15.6
Shorthorn	7.0±0.5	207.0±5.8	147.8±7.5	1437.7±104.4	1983.4±104.3	9.8±0.3	595.6±13.0

Linear contrasts between breed groups for characters that expressed significant breed group differences were estimated as a deviation from the British (Shorthorn-cross) mean.

European-cross cows produced 34.5 kg heavier calves at weaning than Shorthorn-cross cows ($P<0.01$), followed by dairy-cross cows (29.8 kg; $P<0.01$). Friesian-, Charolais- and Simmental-cross cows weaned significantly heavier calves than Shorthorn-cross cows when measured on a per calf or per year-in-herd basis.

European-cross cows expressed slightly heavier mature cow sizes than Shorthorn-cross cows, although this difference was not significantly different from zero. Brahman-cross cows were 93 kg ($P<0.01$), Sahiwal-cross 88 kg ($P<0.01$), Friesian-cross 35 kg ($P<0.01$) and Jersey-cross 135 kg ($P<0.01$) lighter than Shorthorn-cross cows.

There were no differences between breed groups within biological type for weaning weight on a per calf or per year basis. Friesian-cross cows expressed 100 ± 20 kg heavier mature cow weight than Jersey-cross cows ($P<0.01$).

Linear regression coefficients of maternal production on mature cow size were not found to be significantly different from zero, but quadratic coefficients were ($P<0.01$). All regressions were negative, which showed a tendency for increases in mature cow size to decrease lifetime productivity. These results are in agreement with the previous studies of Stewart and Martin (1981), but are at variance with those of Marshall et al. (1984), who reported a positive but non-linear relationship between mature cow size and measures of maternal productivity.

Over seven breed groups optimal mature cow sizes were 516 kg (AT), 526 (AWWT), 530 (AWWY), 525 (CWWT), 526 (NW) and 539 (TBP). Years in herd expressed the smallest optimal mature size, along with CWWT. The main measure of reproduction in the present study, (NW), showed a similar optimal mature cow size to AWWT (per calf), but smaller optimal mature size than that for AWWY and TBP. These results are not as conclusive as those of Stewart and Martin (1983) and Marshall et al. (1984), who showed that as emphasis shifted from reproduction to growth, there was an increase in optimal mature cow size.

There has been considerable discussion of the relationship between cow size and productivity, (e.g. Long et al 1975, Stewart and Martin 1983, Marshall et al. 1984). The focal point of discussion has been the increased nutrient requirement of the larger cows size (Jenkins and Ferrell 1984). Studies of crossbreeding systems generally have led to the recommendation of using larger terminal sire breeds with smaller sized maternal breeds (Long et al. 1975). Stewart and Martin (1983) and Marshall et al. (1984) in a study of purebred Angus and Red Poll cattle, respectively, showed a positive but non-linear relationship between cow size and measures of maternal productivity. The non-linear relationship indicated an optimal cow size of near 485 kg for Angus cattle and 605 kg for Red Poll cattle. In studies of the relationship between cow size and maternal productivity of Angus and Shorthorn crossbred cows, Stewart and Martin (1981) showed a negative relationship, such that larger cows tended to be less productive.

In the present study, quadratic regressions of measures of maternal production on mature size were negative, indicating that as cow size increased beyond an optima, productivity decreased. The significant differences in regression of lifetime productivity on mature size within breed group demonstrates that the relationship differs among breed types. Therefore, general statements of optimal size across breeds are inappropriate. Breeding programs must consider this variation among breeds. These findings support the differences in optimal size

for Angus and Red Poll cattle reported by Stewart and Martin (1983) and Marshall et al. (1984), respectively, and further support the concept of utilizing smaller crossbred cows. However, if the salvage value of the cow is included as an output of the production system, a larger cow size may be desired.

In a production situation, the more desired breed group will be dependent upon the economic advantage of having more calves as opposed to bigger calves. Additionally, mature cow size will need to be considered. If cow herd nutrient availability is limited, the larger cow sizes may be detrimental, as is exemplified by the negative relationships found between cow size and productivity in these data. However, if beef derived from cull cows is of similar value to that from calves, the larger breed groups may be more profitable.

The results of the present study demonstrate the importance of having a well defined objective to a breeding program. Selection on growth alone may produce a larger cow than the optimum for reproduction while selection for reproduction alone would result in a suboptimal cow relative to growth. The development of a well defined breeding program requires optimising the relationship between the traits in the objective and the characters used as selection criteria (Ponzoni and Newman, 1989). Mature cow size is but one character that has an impact on profitability in a breeding program, and therefore should be considered as a candidate for inclusion in the breeding objective.

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