EVIDENCE OF NATURAL SELECTION IN A HERD OF HEREFORD-SHORTHORN CATTLE IN THE TROPICS

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SUMMARY

Genetic and environmental trends for growth from birth to two years of age (final weight) were estimated in a herd of Hereford x Shorthorn cross animals by fitting a multi-trait mixed animal model. Within the herd a line (HSS) selected for growth and a control line (HSR) in which directional selection was avoided were maintained. Environmental trends for growth over the period 1966 to 1981 were not significant. Genetic trends for weaning weight, post weaning gain and final weight in the HSS line were 0.41, 1.02 and 1.42 kg/year respectively. Significant trends in the HSR line were also recorded for post-weaning gain (0.89 kg/yr) and final weight (0.99 kg/year). Within the HSR line, mortality of slower growing calves before two years of age occurred and heavier bulls produced more progeny. It was concluded that natural selection for animals better adapted to the tropical environment was operating.

INTRODUCTION

Following European settlement, Bos taurus cattle were introduced into Northern Australia. Although unsuited to the climate, parasites and grazing conditions in the tropical areas, management systems were developed which achieved satisfactory production levels. Bos indicus cattle have now largely replaced Bos taurus breeds such as the Hereford and Shorthorn in most tropical areas although some Bos taurus herds remain where parasite and nutritional stress are only moderate.

This study, which complements an earlier study by Frisch (1981), reports on genetic changes in growth within a selected and control line of Hereford x Shorthorn cross cattle, managed in a tropical environment in much the same way as Bos indicus cattle are now raised commercially. The results support, in a quantitative way, the suggestion that natural selection was acting within the control line.

MATERIALS AND METHODS

(i) Data

Data analysed in this study were from a herd of Hereford x Shorthorn cross (HS) cattle maintained at the National Cattle Breeding Station, Belmont near Rockhampton, Queensland. Formation and general management of the HS line has been reported by Frisch (1981). Prior to the 1966 calf crop no directional selection was practised within the herd. In 1967, 34 cows were mated to a selected bull to initiate the selected HS (HSS) line. Numbers were increased over time and from 1970, 3-4 bulls were mated to 100-130 cows annually. In the unselected control line (HSR), numbers were maintained at 3 bulls and approximately 100 cows mated per year. Records from animals born between 1966 and 1981 were analysed.

Bulls were single sire mated at two years of age and replaced annually. In the HSR line, replacement bulls plus reserves from the 1966-1974 calf crops were chosen at weaning (six to seven months of age), at random from within each sire progeny group. From 1975, HSR bulls were chosen from around the line mean for weaning and final weight. On average, only 25-50% of bull calves were retained until two years of age. Selection criteria in the HSS line changed over time. In all years approximately half of the bull calves were culled at weaning on pre-weaning growth rate. From 1970 onwards, dam age corrections for weaning weight were applied. Final selection was based on tick resistance and post-weaning gain (until 1973) or final weight at two years of age (after 1973). In addition, some selection on heat tolerance (1968-73 and 1977), post-weaning feed intake (1968-72) and a fertility index of female relatives (1973-77) was practised. Single trait divergent selection for growth was practised in the 1972 and 1978 calf crops. In several years parasite or nutritional treatments were imposed, in which case selection was carried out within management groups.

All heifers generally entered the breeding herd at two years of age. Cows were culled for reproductive failures at an intensity determined by the number of heifers available.

(ii) Genetic and environmental trends

The traits analysed were birth weight, age-adjusted pre-weaning gain and age-adjusted post-weaning gain (gain from weaning to two years of age). Weaning weight and final weight were subsequently calculated by summation. A multi-trait mixed animal model incorporating a full numerator relationship matrix as described by Quaas and Pollak (1980) was fitted to the data. Equations for each animal included fixed effects, direct genetic effects for birth weight, pre-weaning gain and post-weaning gain, and maternal genetic and permanent environmental effects for birth weight and pre-weaning gain. The fixed effects, totalling 160 for each trait, were year of birth (1966-81), sex (M or F) and management group (parasite or nutritional treatment). Data were pre-adjusted for dam age and previous lactational status (see Hetzel et al. 1990). The genetic and environmental variances used were the pooled estimates reported by Hetzel et al. (1990).

Included in the analysis were a total of 1985 animals, of which 155 were base animals with unknown parentage and no traits recorded. The 14375 equations were reduced to 5240 by absorbing equations for non-parents, prior to solving by 150 rounds of iteration. Back solutions for non-parents were obtained as suggested by Quaas and Pollak (1980).

Genetic trends for each trait were calculated by fitting linear regressions over time to mean estimated breeding values of all animals born each year. Environmental trends were estimated from regressions over time of mean performance (with any genetic trend removed) of female progeny, untreated for any parasites or without nutritional supplement. Selection differentials were calculated according to James (1986).

RESULTS

Growth of the HS animals was consistently low but fluctuated greatly from year to year due to seasonal variation. Average birth weights, pre-weaning gains and post-weaning gains of untreated heifers were 30.5, 94 and 78 kg respectively. Environmental trends for both lines combined over the 16 years were not significant ($P > 0.05$) for all three traits. The trend for preweaning gain was greatest (-1.51 kg/year ± .77). However strong negative trends for pre-weaning gain and to a lesser extent, in post-weaning gain were observed after 1974, which coincided with an increase in stocking rate.

Table 1 Estimates of realised selection differentials (kg) and genetic trends (kg/year) in the selected (HSS) and random (HSR) Hereford-Shorthorn lines between 1966 and 1981

		Line	
		HSS	HSR
Realised selection differentials			
Birth weight	- males	3.8	3.2
	- females	2.9	2.6
Pre-weaning gain	- males	25.3	6.4
	- females	24.8	8.6
Post-weaning gain[1]	- males	48.3	30.1
	- females	41.8	36.3
Genetic trends			
Birth weight	- direct	0.00 ± .03	-0.04 ± .03
	- maternal	0.01 ± .01	0.01 ± .01
Pre-weaning	- direct	0.30 ± .07	0.03 ± .10
	- maternal	0.10 ± .04	0.13 ± .08
Weaning weight	- direct	0.30 ± .07	-0.01 ± .11
	- maternal	0.11 ± .04	0.13 ± .08
Post-weaning gain		1.02 ± .24	0.89 ± .22
Final weight		1.42 ± .24	0.99 ± .34

[1] No adjustment made for post-weaning culling or mortality

The realised selection differentials over the 3.1 generations of selection are given in Table 1. Positive selection differentials were observed for all traits in both lines but were three times higher for pre-weaning and around 50% higher for post-weaning gain in the HSS line. The calculated selection differentials for post-weaning gain are a minimum estimate because no allowance was made for culling before final weighing. Since sequential selection on both weaning weight and tick resistance was practised, no statistical adjustment was possible. Sex differences in selection differential are due to uneven sex ratios in sire progeny groups. When considered in either absolute terms or in standard deviation units, most selection pressure in the HSS line was focussed on post-weaning gain.

Genetic change in the two lines was cyclical due to genetic sampling effects being highlighted by the annual replacement of bulls. Consequently line differences varied over time from small to large. Overall genetic trends in the HSS line were significant ($P \leq 0.05$) for all traits except birth weight (Table 1). Expressed relative to the average performance of untreated heifers, rates of change for HSS were 0.3% and 0.6% per year for weaning weight (direct plus maternal) and final weight respectively. However, if allowance is made for the years when no directional selection was practised, trends in the HSS were 0.4% and 0.8% per year for weaning and final weight respectively. Expressed as a deviation from the control (HSR) line, the rate of response in final weight was 43% lower than estimated by the mixed model analysis.

The estimated genetic trends in the HSR line were non significant for birth weight and pre-weaning growth, though strongly positive for maternal pre-weaning gain i.e. milk production (Table 1). Trends were highly significant ($P < 0.05$) for post-weaning gain and final weight and respectively 13% and 30% lower than estimates for the HSS line. The positive trends in the control line reflect the accumulated selection differential.

DISCUSSION

Genetic trends estimated using mixed model procedures are directly proportional to the assumed genetic variances and covariances. The genetic parameters used in this study were estimated from zebu cross and HS records collected in the same environment. However the relative difference in genetic trends between the HSS and HSR lines is unaffected by the choice of genetic parameters unless all variation is environmental in origin, i.e. trends in both lines would change by the same proportion if higher or lower parameters were assumed.

Given that selection differentials in the HSR line were expected to be close to zero, it is clear that unintentional selection for faster growing animals (post-weaning) has occurred. The HSR bulls available for final selection represented only 25-50% of the calf crop due to culling at weaning. The average weaning weight of surviving bulls at two years was nearly always higher than the entire group at weaning. Thus preferential survival of heavier (at weaning) bulls has occurred. A similar situation occurred with heifers even though no culling took place. Selection pressure also arose through the greater number of progeny contributed by faster growing bulls (data not shown).

Reasons for the unintentional selection in the HSR line relate to why lighter animals did not survive to the age at which selection was carried out and why heavier bulls produced more calves. Frisch (1981) reported that higher growth rate in the HSS line, when compared with the HSR, was due to greater heat tolerance, higher worm resistance and lower maintenance requirement i.e. the selection response was due to a greater ability of animals to cope with the environmental stresses. Since the HS is a Bos taurus cross, the initial level of environmental adaptation was very low. Thus artificial selection focussed on genetic variation for these characteristics. It is concluded that natural selection was operating in the same way within the HSR line. Frisch (1981) also suggested that survival and higher reproductive rate of heavier animals in this line was due to greater adaptation to the tropical environmental stresses. In conclusion, it appears that natural selection in the HSR line operated in a similar way though at a slower rate to artificial selection in the HSS line.

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