ESTIMATES OF DIRECT AND MATERNAL HERITABILITIES FOR GROWTH AND LIFETIME PRODUCTION TRAITS IN BEEF COWS

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SUMMARY

Lifetime records on 344 purebred Hereford (HE) and 517 multibreed Beef Synthetic #1 (SY1) cows born from 1966 to 1975 were analysed to provide estimates of genetic parameters for growth traits measured early in life and measures of longevity and lifetime production. The cows were managed under a stringent culling policy where a heifer or cow failing to wean a calf each year was culled. Estimates of direct heritability were higher than maternal heritability for all traits, except weaning weight for which the pattern was reversed. Estimates of direct heritability for growth traits (except weaning weight, with low estimates) were moderate to high (0.23 - 0.68), while those for lifetime production traits were moderate (0.22 - 0.37). Total heritability for the lifetime production traits were low, ranging from 0.04 to 0.17. Estimates of direct and total heritabilities were higher in the multibreed SY1 than the purebred HE breed group for all the traits studied. Estimates of genetic correlation between direct and maternal effects were nagative for all traits in both breed groups except for yearling weight of HE cows which was close to zero.

INTRODUCTION

The length of the productive life of a cow greatly affects the productivity of the herd and the economic returns to the enterprise. While there are some reports on the heritability and other genetic parameters of longevity in dairy cattle, very little information is available in beef cattle (Tanida et al., 1988; Morris et al., 1993). Also lacking is information on the additive direct and additive maternal effects on longevity and lifetime production traits in beef cattle. The objective of this paper was to estimate additive direct and additive maternal heritabilities of growth and lifetime production traits, in a purebred Hereford and a multibreed Beef Synthetic cow herd managed under a stringent culling policy.

MATERIALS AND METHODS

Lifetime records on beef cows born from 1966 to 1975 from two genetically distinct breed groups; a purebred Hereford (HE) and a multibreed Beef Synthetic #1 (SY1), at the University of Alberta ranch at Kinsella, Alberta, Canada, were used in this study. The two breed groups had been maintained and managed similarly since 1961 and had been subjected to the same selection program. The HE was a purebred group, while the SY1 was composed of approximately 33% Charolais, 33% Angus and 20% Galloway breeding with small contributions from other beef breeds. Within each breed group, males used for breeding were selected on the basis of equal weighting of adjusted weaning weight and postweaning average daily gain. Males which required more than minimal assistance at birth were not eligible for breeding. There was no direct selection of heifers and cows. All sound heifers were bred as yearlings to calve as 2-year olds. Cows and heifers were exposed to bulls for 60 days in the breeding season each year in single sire matings of 25 females per bull. Under a stringent culling policy, heifers and cows failing to wean a calf each year were culled. Females which required Caesarian section at calving were culled. Females were also culled for pendulous udders, large and bottle teats, and for leg and feet problems. Further details on the management, culling policy, breeding plan and productivity of the cows have been reported by Arthur et al. (1992, 1993).

Longevity (LONGEV) of a cow was computed as the age (yr) at disposal. It represented productive longevity since any cow failing to wean a calf each year was culled. Lifetime production traits computed were cumulative number of calves weaned (NUMWEAN) and cummulative weight (kg) of calves weaned (WTWEAN). In the computation of WTWEAN, the weights of female calves were adjusted to male basis, as described by SHARMA et al. (1982). Growth traits measured early in the life of the cow were also used and they included weaning weight (WEANWT) and yearling weight (YEARWT), which were adjusted to 180 and 365 days, respectively, and birth weight (BIRTHWT), all measured in kg.

All the cows had been disposed (Arthur et al., 1992) by the time of data analyses hence the analyses involved records on ten complete cohorts (year of birth groups). The numbers of animals (including parents), records, dams and sires were 485, 344, 194 and 67, respectively, in the HE data set, and 696, 517, 282 and 72, respectively, in the SY1 data set. All analyses were conducted within breed group. Variance and covariance components were estimated using a derivative-free restricted maximum likelihood (DFREML) procedure (Meyer, 1991) and fitting a univariate animal model with direct and maternal additive effects as random effects in addition to the error term. Year of birth of cow with 10 levels (1966, ..., 1975) and age of cow's dam with 5 levels (2, 3, 4, 5, ≥6 years) were significant effects obtained from a preliminary analysis, and were included in the model as fixed effects. All known pedigree information was included in the analysis to increase the accuracy of estimation through additional relationships between animals. Estimates of direct (h_A^2) and maternal (h_M^2) heritability were obtained as ratios of the additive direct and the additive maternal variances, respectively, to the phenotypic variance. Estimates of total heritability (h_T^2) as defined by Willham (1972) were also computed.

RESULTS AND DISCUSSION

Means, standard errors and other descriptive statistics of the traits studied are presented in Table 1. Beef Synthetic #1 cows were heavier than Hereford cows at all ages. Longevity and the lifetime production traits followed a similar pattern, with values for Beef Synthetic #1 being higher than those for Hereford cows. Means for longevity and lifetime production traits were lower than those reported in other studies (Rohrer et al., 1988; Tanida et al., 1988; Morris et al., 1993). This result is not unexpected since the culling policy in this study was more stringent than those of the other studies. A detailed discussion of these results has been presented earlier (Arthur et al., 1993).

Table 1. Descriptive statistics of traits measured early in life and measures of lifetime production of cows

Trait	Breed†	Mean	SE	Median	Max	Min
BIRTHWT (kg)	HE	32.4	0.2	32	49	16
	SY1	34.2	0.2	34	53	20
WEANWT (kg)	HE	172.9	1.4	172	230	75
	SY1	202.7	0.9	202	270	145
YEARWT (kg)	HE	250.2	1.8	252	366	80
	SY1	273.4	1.3	272	385	170
LONGEV (yr)	HE	3.6	0.2	3	13	1
	SY1	4.5	0.2	3	16	1
NUMWEAN	HE	2.0	0.2	1	12	0
	SY1	2.7	0.2	1	15	0
WTWEAN (kg)	HE	319.9	28.1	160	1989	0
	SY1	540.8	33.2	211	3318	0

†HE, Hereford; SY1, Beef Synthetic #1.

Estimates of genetic parameters of traits measured early in life and measures of longevity and lifetime production of cows are presented in Table 2. Growth traits measured early in life were all moderately to highly heritable, and the estimates were within the range of published estimates summerized by Baker (1980) and Mohiuddin (1993), except h_A^2 and h_T^2 for WEANWT of HE cows which were on the lower end of the reported values. There are no published reports of estimates of genetic parameters for longevity and lifetime production traits which were based on additive direct and maternal effects for both beef and dairy cattle. Compared to published heritability estimates based on paternal half sib correlations or daughter-dam regressions for beef cattle (Tanida et al., 1988; Arthur and Makarechian, 1992; Morris et al., 1993), the h_A^2 estimates from this study were higher. Estimates for dairy cattle based on the two procedures range from 0 to 0.39, with a mean around 0.12. The estimates for h_T^2 fall within this range. Except for WEANWT, estimates for maternal heritability in both breed groups were lower than direct heritability, indicating that the traits were determined more by the genetic characteristics of the animal than by those of the dam. The higher maternal heritability estimates for WEANWT is in agreement with those estimates published by Baker (1980) and Mackinnon et al. (1991). Estimates of direct-maternal genetic correlation (r_{AM}) were nagative for all traits in both breed groups except for YEARWT of HE cows which was close to zero.

Table 2. Estimates† of direct and maternal heritability (± standard error) and other genetic parameters for traits measured early in life and measures of lifetime production of cows

Trait	Breed‡	h_A^2	h_M^2	c_{AM}	r_{AM}	h_T^2
BIRTHWT	HE	0.53 ± 0.01	0.18 ± 0.01	-0.11	-0.35	0.46
	SY1	0.68 ± 0.02	0.16 ± 0.01	-0.15	-0.44	0.54
WEANWT	HE	0.06 ± 0.01	0.41 ± 0.01	-0.15	-0.98	0.03
	SY1	0.14 ± 0.01	0.27 ± 0.01	-0.09	-0.45	0.14
YEARWT	HE	0.23 ± 0.01	0.13 ± 0.01	0.01	0.02	0.30
	SY1	0.56 ± 0.02	0.03 ± 0.01	-0.09	-0.65	0.45
LONGEV	HE	0.22 ± 0.01	0.12 ± 0.01	-0.16	-0.99	0.04
	SY1	0.29 ± 0.01	0.09 ± 0.01	-0.16	-0.99	0.10
NUMWEAN	HE	0.24 ± 0.02	0.11 ± 0.01	-0.16	-0.99	0.05
	SY1	0.37 ± 0.02	0.07 ± 0.01	-0.16	-0.99	0.17
WTWEAN	HE	0.30 ± 0.01	0.06 ± 0.01	-0.13	-0.94	0.14
	SY1	0.37 ± 0.02	0.07 ± 0.01	-0.15	-0.97	0.17

† h_A^2, direct heritability; h_M^2, maternal heritability; c_{AM}, direct - maternal covariance, expressed as a proportion of phenotypic variance; r_{AM}, direct - maternal genetic correlation; h_T^2, total heritability.
‡HE, Hereford; SY1, Beef Synthetic #1.

The estimates of total heritability for the growth traits measured early in life were within the range of reported values summerized by Baker (1980) and Mohiuddin (1993), except for WEANWT of HE cows which was lower, due to the higher estimate of maternal heritability and the high negative direct-maternal correlation. Total heritability is a measure of that fraction of the selection differential that would be realized if selection were based on the phenotypic value of the offspring. Given the moderate to high h_T^2 values for the growth traits (except WEANWT for HE), it is expected that the selection for these traits would be effective even though there

are antagonistic associations (negative r_{AM}) between direct and maternal effects. Selection would be more effective if r_{AM} was zero. Although direct selection for longevity and lifetime production is not practical, the low h_T^2 values for these traits indicate that response to selection for these traits will be minimal. Estimates for direct heritability and total heritability were higher in the multibreed SY1 than the purebred HE herd for all the traits studied. Similar findings were obtained by Bertrand and Benyshek (1987), Liu et al. (1991) and Tawah et al. (1993). This result could be attributed to the larger genetic variation in multibreed synthetic herds.

ACKNOWLEDGMENTS

The assistance of G. MINCHAU and the staff of the Kinsella ranch, and the technical support provided by R. Weingardt is acknowledged. Special thanks to K. Meyer for the use of her DFREML program.

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