GENETIC AND ENVIRONMENTAL TRENDS IN PREWEANING PERFORMANCE OF BEEF SHORTHORN CALVES

Raising as many heifers as possible and introducing unrelated sires regularly is a common practice in most beef herds. The introduced sires are usually selected on the basis of their performance, insofar as this is known, in certain characters assumed to have economic importance. The rate of preweaning gain is one of the most important characters because it directly affects the returns in terms of kilograms of weaned calves marketed.

The purpose of the present study is to report on the changes in preweaning performance of calves over a period of 19 yr, to estimate the effects of various environmental factors, to calculate genetic parameters and try to identify the genetic and environmental portions of the observed phenotypic change by using a systematic approach.

The data used were birth and weaning records of 892 Shorthorn calves (progeny of 249 cows and 19 sires) born from 1951 to 1969 at the Lennoxville Research Station. The sires used were introduced from other herds to avoid inbreeding. They were all selected for high rate of gain. At the time of the analysis, birth and weaning records of only six bulls were available, and these were all above the Lennoxville herd average. Most of the bulls were used from 2 to 4 consecutive yr, only one bull was used for 5 yr, and eight bulls were used for 1 yr each.

Cows were mated naturally on pasture starting in May of each year. They were later wintered on hay and grass silage given ad libitum in free stall barns. The calves were born in the period from March to May and were left with their dams until weaning, usually in October. Most of the healthy, well-developed female calves were raised for replacement. There was no intentional culling of cows, except to eliminate those that failed to conceive within 2 yr and those that showed extremely low milk production. Others had to be eliminated due to physical abnormalities, diseases, or accidents. Calf weaning weights were adjusted to 210 days by calculating the preweaning average daily gain, multiplying it by 210, and adding birth weight.

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The effects of sex, type of birth (single or twin), years, and age of dam were estimated by the least squares method of fitting constants.

Male and single calves were significantly ($P < 0.01$) heavier than females and twins by 1.48 and 7.58 kg at birth and by 12.0 and 18.3 kg at weaning (Table 1). Type of birth was the most important source of variation on birth and weaning weights accounting, respectively, for 64% and 17.5% of the total variation, whereas sex was the least important source accounting for only 2.4 and 8.9%, respectively.

Birth and weaning weights of calves born to young cows 2 and 3 yr old were significantly ($P < 0.05$) lighter than those born to older cows (Table 1). It was estimated by fitting curves that the calves with the maximum weight at birth and weaning were those born to cows 7.6 and 8.2 yr old, respectively. The effect of age of dam on calf weights was 6.1% of the total variation at birth and 13.3% at weaning.

Figure 1 presents the yearly changes in calf birth and weaning weights obtained from the least squares analyses. The years 1960–62 were characterized by markedly lighter birth weights. Weaning weights in 1951 were exceptionally high and dropped sharply in the last 3 yr 1967–69. From fitting a regression the increase in birth and weaning weights over the years was estimated to be 0.14 and 1.17 kg, respectively (year 1951 was excluded from the analysis for weaning weight because only few records were available and those were unreasonably high). The effects found for sex and type of birth of calf and age of dam in the present study were similar to those reported in the literature (reviewed by Petty and Cartwright 1966, and Molinuevo and Vissac 1972).

Least squares constants were used to adjust the data to a common basis (single female born to 5-yr-old cows) and the adjusted data were then used to estimate genetic parameters. Repeatabilities were esti-

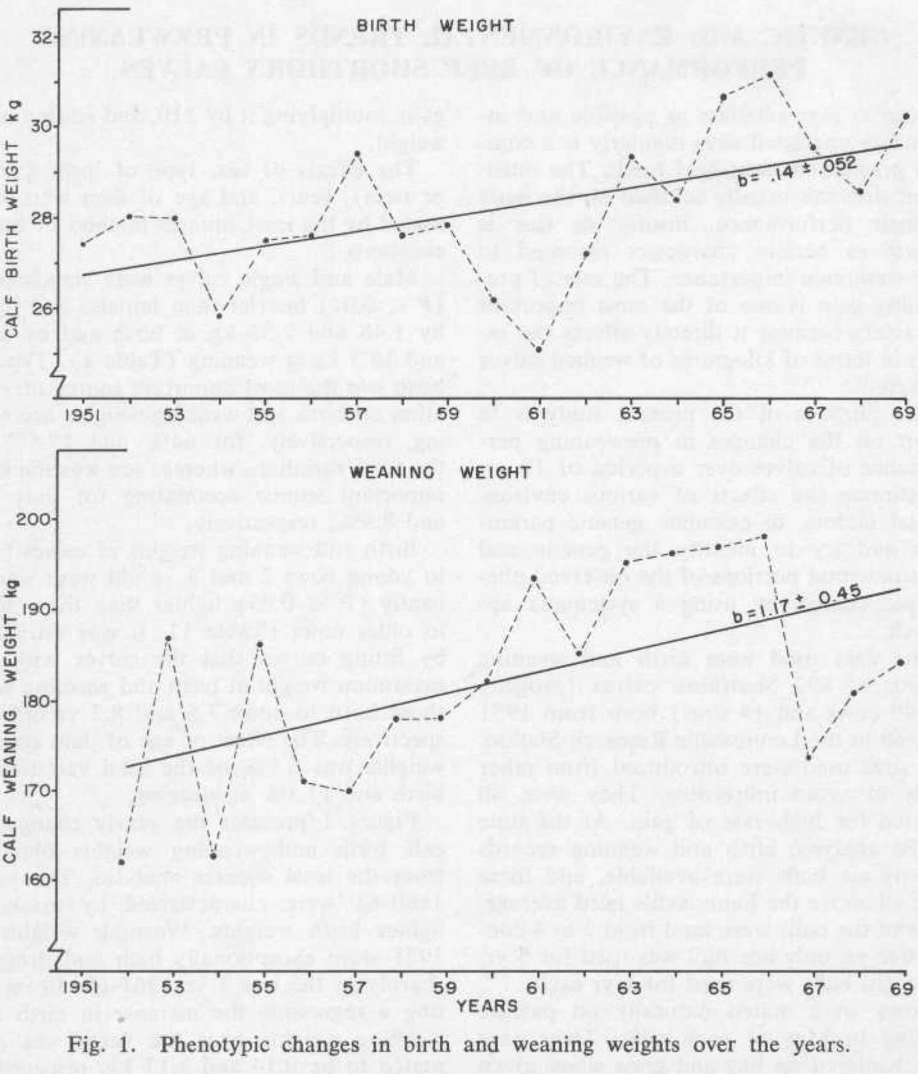

Fig. 1. Phenotypic changes in birth and weaning weights over the years.

mated as intra-cow correlation (Dickerson 1969). Estimates of heritability and genetic correlation were obtained by intra-sire regression of offspring on dam and within-years sire component of variance (Dickerson 1969). The estimates were weighed by the inverse of their variance and pooled.

The repeatability and pooled heritability estimates were 0.41 and 0.21 for birth weight, and 0.25 and 0.32 for weaning weight respectively (Table 2). The pooled genetic correlation between birth and weaning weights was 0.74 and the phenotypic correlation was 0.29.

The phenotypic correlation and the genetic paramenters calculated from the present data are within the range of estimates reported in the literature (reviewed by Petty and Cartwright 1966, and more recently by Molinuevo and Vissac 1972). The pooled heritability estimate for birth weight (0.21) was lower, however, than the 0.40–0.44 average given in this review.

Most of the sires were kept in the herd for more than one breeding season. Thus, some cows were mated to the same bulls in two or more consecutive years, producing full sibs, and others were mated to different

Table 1. Least squares constants for birth and weaning weights of calves

	Birth wt (kg)			Weaning wt (kg)		
	No.	Constant	SE	No.	Constant	SE
μ	892	28.08	0.38	753	183.3	2.5
Sex						
Males	420	.74 *a**	0.11	399	6.0 *a*	0.8
Females	472	−.74 *b*	0.11	454	−6.0 *b*	0.8
Type of birth						
Singles	871	3.79 *a*	0.37	734	9.1 *a*	2.6
Twins	21	−3.79 *b*	0.37	19	−9.1 *b*	2.6
Age of dam (yr)						
2	104	−3.79 *a*	0.35	83	−23.7 *a*	2.5
3	210	−1.86 *b*	0.27	173	−14.5 *b*	1.9
4	152	.22 *c*	0.29	120	−1.0 *c*	2.1
5	112	.24 *c*	0.33	101	−1.0 *c*	2.3
6	107	1.35 *d*	0.34	95	5.7 *de*	3.4
7	82	1.01 *cd*	0.38	75	9.7 *de*	2.6
8	53	1.40 *cd*	0.45	44	13.1 *c*	3.2
9	37	.42 *cd*	0.52	31	1.4 *cd*	3.7
10	21	1.50 *cd*	0.67	20	3.7 *cde*	4.4
11	12	−.50 *bcd*	0.67	10	6.6 *cde*	5.9

*Deviations followed by different letters are significantly ($P < 0.05$) different.

bulls, producing half-sibs. It was therefore possible to estimate the yearly genetic and environmental changes using the data adjusted for sex and type of birth of calf and age of dam. The following procedure (modified from Smith 1962) was employed (Fig. 2). The difference in average weights between full sibs produced in consecutive years measured the environmental change (e) between the 2 yr, because the average genetic makeup of the calves was taken to be the same. The difference between maternal half-sib calves produced in 2 consecutive yr measured the environmental plus one-half the genetic

Table 2. Repeatability, heritability, genetic, and phenotypic correlations

	Birth wt	Weaning wt
Intra-cow correlation (repeatability)	.41±.04†	.25±.05
Heritabilities		
Sire component‡	.21±.03	.35±.04
Regression of offspring on dam§	.21±.10	.13±.11
Pooled h^2 (weighted)	.21	.32
Genetic correlations		
Sire component‡	.72±.07	
Regression of offspring on dam	.77±.11	
Pooled r_g (weighted)	.74	
Phenotypic correlation‖	.29	

†Standard error.
‡24 df Sires within years, 605 df residual.
§519 Dam-offspring pairs within 55 sire within year of birth of dam groups.
‖Estimated from the residual mean squares and covariance after correcting for sex, type of birth, age of dam, and years.

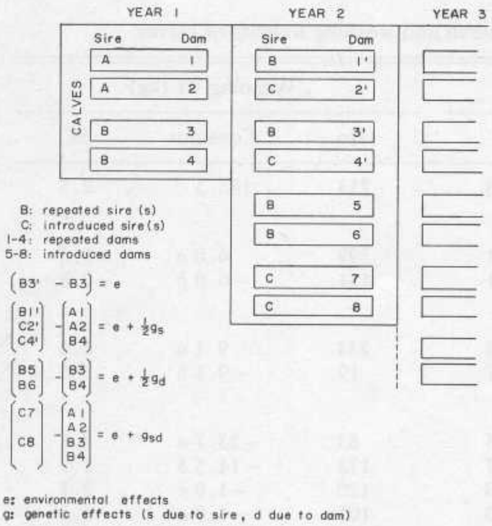

Fig. 2. A diagram of the herd structure to illustrate how the effects were estimated.

change due to sire ($e + \frac{1}{2}g_s$). The difference between parental half-sib calves produced in consecutive years by the newly introduced cows measured the environmental plus one-half the genetic change due to dam ($e + \frac{1}{2}g_d$). The difference between the calves of newly introduced parents and those of the preceding year measured the environmental plus the genetic changes ($e + g_{sd}$). The genetic change per year was estimated in this study from $[(e + \frac{1}{2}g_s) + (e + \frac{1}{2}g_d) - 2e]$. It can also be estimated from $[(e + g_{sd}) - e]$. Both genetic and environmental changes were regressed against years.

The phenotypic change in birth weight observed (.14 kg/yr) was partitioned as $0.11 \pm .06$ of genetic origin and 0.053 ± 0.04 kg due to improved environment. For weaning weight, however, although there was an estimated genetic gain of 0.48 ± 0.27 kg per year, there was a negative environmental change of -0.58 ± 0.28 per year. Other environmental factors and management procedure not accounted for in this study may be the reason for this negative environmental change. The validity of this method in determining the genetic trends depends, to a great extent, on the accuracy of estimating and correcting for the effects of various environmental factors and especially age-of-dam effect, which is confounded with the genetic trends.

Résumé

On a analysé les données se rapportant à la naissance et au sevrage de 892 veaux Shorthorn, issus de 249 vaches et 19 taureaux. Les buts étaient d'évaleur l'amélioration de la performance sur une période de 19 ans, d'estimer l'influence de divers facteurs de milieu, de calculer les paramètres génétiques et d'identifier les portions de génétique et d'environnement des changements phénotypiques observés. Les veaux mâles et uniques pesèrent 1.5 et 7.6 kg de plus que les femelles et les jumeaux à la naissance et 12.0 et 18.3 kg de plus au sevrage. Le poids des veaux à la naissance et au sevrage s'est accru de façon régulière, par rapport à l'âge de leurs mères, jusqu'à l'âge de 8 ans, puis a diminué par la suite. L'année, le sexe, le type de naissance, et l'âge de la mère ont influencé de façon significative les deux poids. La fréquence de répétition et les estimés groupés d'héritabilité furent de 0.41 et 0.21 pour le poids à la naissance et 0.25 et 0.32 pour le poids au sevrage respectivement. Les correlations phénotypiques et génétiques groupées entre les deux poids furent de 0.29 et 0.74 chacun. Les poids à la naissance et au sevrage ont augmenté chacun de 0.14 ± 0.05 et 1.17 ± 0.46 kg par année. Le changement génétique annuel fut de 0.11 kg pour le poids à la naissance et de 0.48 kg pour le poids au sevrage.

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