SOME FACTORS AFFECTING BIRTH WEIGHT OF BEEF CALVES

by

HUGUETTE M. TSATSKIN

Ingenieur Agronome,
Institut National Agronomique, Paris, France, 1952

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INTRODUCTION

Although limited conclusive information is available at present, many research workers have made studies of the birth weight of beef calves in recent years. Birth weights have usually been considered in beef cattle progeny tests and have become of special interest because of their relationship to the economic characters.

The birth weight of calves can be obtained quite easily by most purebred breeders, and since it is one of the first available measurements in the animal's life, an application of birth weight considerations in breeding techniques may prove expeditious to cattle breeding improvement.

Several investigations provide definite evidence to justify this assumption.

Knapp et al. (11) concluded that prenatal development, as expressed in weight at time of birth, influences postnatal growth and performance in beef cattle. Data obtained by Dawson et al. (2) on 72 Shorthorn steers showed significant negative correlation coefficients between birth weight and the number of days required to reach a standard body weight, indicating that large calves at birth tend to grow faster. Lush (16) found a tendency for large initial weight to be associated with large gain, high dressing percentage, and high final value of steers on feeding tests.

There is evidence to indicate that the effect of birth weight is most evident in young animals whereas its influence tends to disappear in later life or upon mature development. Dawson et al.

(2) found that sheep manifest marked birth weight effects at three months of age but these become slight at the age of one year. This observation suggests that the influence of birth weight may be dependent upon age at the time of slaughter in meat animals.

Kusner (14) reported a rather high correlation coefficient between birth weight and the weight at 18 months of age in 285 Kazak-Kalmuck crossed Hereford heifers maintained at two different stations, and stressed the advisability of birth weight consideration in cattle selection.

It is apparent that the birth weight of calves influences postnatal growth and production performance. It may likewise be noted that large calves at birth have been observed to possess a certain advantage in rate of growth.

Although this relationship and evident advantage of heavy birth weight in calves exist, the possibility of heavy birth weights causing fetal dystocias must not be ignored. At present, there is a lack of experimental evidence to justify any conclusions in regard to the limitations which might be presented by this problem.

This paper will present a study of some of the factors which influence the birth weight of beef calves. A review of the literature was made for a better understanding of methods of analysis and for comparison of experimental results obtained by other research workers prior to this investigation.

REVIEW OF LITERATURE

Several studies on the birth weight of calves have been conducted at different stations. Most of these investigations have shown that numerous factors influence prenatal growth in cattle. A review of the literature was made and the factors generally considered to affect birth weight are discussed under separate headings.

Age of Cow at Time of Calving

Knapp et al. (10) studied the effect of age of the dam on the birth weight of beef calves and found that the calves from two-year-old cows were generally small whereas four-year-old cows tended to produce the heaviest calves of the cow age groups studied. An analysis of variance of the calf birth weights between cow age groups gave a probable significant difference; however, since the greatest difference in birth weights was ten pounds, they concluded that the age of dam was of little consequence in the production efficiency of range cows.

Dawson et al. (2) found that calf birth weights tended to increase with the age of dam until the age of six years after which there was no further effect. The average increase of calf birth weight per month increase of age of dam until six years was 0.23 pound for male and 0.20 pound for female calves. The correlation coefficients between calf birth weight and age of dam, within sex and considering cows more than six years of age equivalent to six-year-old cows, were 0.45 for males and 0.35 for females.

According to Venge (21), who conducted an experiment which included 670 Swedish red and white and 429 Red Danish cows, calves from heifers were 8 to 12 per cent lighter at the time of birth than those from mature cows.

Burris and Blunn (1) studied the birth weights of 184 Angus, 188 Hereford, and 130 Shorthorn calves and concluded that birth weight tended to increase until the dams were ten years old. The largest difference between any two consecutive age groups of dams was found between two- and three-year-old cows. The regression of calf birth weight on age of dam was 1.043 pounds and the partial regression of birth weight on age of dam was 0.970 pound in multiple regression with length of gestation. These coefficients were highly significant.

Weight of Cow Immediately after Parturition

Knapp et al. (11) stated that changes in the weight of cows due to the medium did not affect the birth weight of calves. They found a correlation coefficient of 0.40 between calf birth weight and weight of dam; however, this was reduced to 0.08 when only the calves from the same cow were considered.

Krasnov and Pak (13) found correlation coefficients of 0.56 ± 0.08 for male and 0.42 ± 0.09 for female between calf birth weight and weight of dam in Tagil cattle.

Dawson et al. (2) computed a multiple correlation coefficient of 0.56 between calf birth weight and weight and age of dam; this coefficient was highly significant.

Length of Gestation Period

Fitch et al. (5) concluded that there was a marked variation in the length of the gestation periods between individual dairy cows. He also found evidence that there was some variation in length of gestation periods between breeds of cattle. Although the data obtained in this experiment did not show a relationship between birth weight and length of gestation period, other studies have indicated that heavier calves tend to be carried for a longer period of time.

This tendency was found by Burris and Blunn (1), who reported a regression coefficient for birth weight of calf on length of gestation period of 0.376. This coefficient was changed to 0.348 upon consideration of the effect of age of dam. They stated that 7.9 per cent of the variance in calf birth weight (7.3 per cent when corrected for age of dam) could be attributed to this factor.

Krasnov and Pak (13) stated that calf birth weight was positively correlated with length of gestation period; however, Piam (19) obtained a statistically non-significant correlation coefficient between calf birth weight and length of gestation period.

Length of Gestation Period, Weight of Dam, and Calving Sequence

Knapp et al. (11) computed a multiple correlation coefficient of 0.62 between calf birth weight and length of gestation period, weight of dam, and calving sequence. They concluded that 38 per cent of variance in calf birth weight could be attributed to these three factors. The partial correlation coefficients were found to be as follows: length of gestation, 0.58; calving sequence, 0.23; and weight of dam, 0.19. The partial correlation coefficient between calf birth weight and length of gestation period was 0.60 for Beef Shorthorns and 0.50 for Milking Shorthorns. The difference between the two types within the same breed was believed to be due to the fact that the Milking Shorthorns were much less uniform.

Sex of Calf

Fitch et al. (5) found male calves consistently heavier than female calves in dairy cattle.

Knapp et al. (11) found a significant difference between males and females in Beef Shorthorns although they did not find a significant difference in Milking Shorthorns. The differences due to sex in the total variance of birth weights were 6.5 per cent and 2.1 per cent respectively, for the two types. It was also mentioned that from 25 to 35 per cent of sex differences were due to differences in length of gestation periods.

Burris and Blunn (1) estimated that only 10 per cent of sex differences was due to differences in length of the gestation period. They found that males in the Angus breed were carried significantly longer than females; however, there was no significant difference between Hereford males and females. It was noted that Hereford males tended to be carried longer whereas females tended to be carried longer than males in Shorthorns.

Year of Birth

Few studies mention the effect of year on birth weight of calves even though years vary with environmental conditions under which experiments are conducted.

Burris and Blunn (1) did not find significant year effects on birth weights of calves. They explained that this might have been due to relatively uniform conditions of management and to the fact that the fetus having, at least during the first half of the gestation period, priority in the dam's body is somewhat protected against nutritional deficiencies by the reserves in the mother's body. This finding was in accordance with Fitch's conclusion in dairy cattle (5), who stated the nutrition of the dam has but little effect on birth weight except in the case of restricted rations.

Season of Calving

According to Knapp et al. (11), the estrus cycle of cattle varies with season and is related to the length of the gestation period. If this is true, there should be differences in birth weight due to the season of calving.

Knapp et al. (11) reported that Beef Shorthorns born in the Fall were heavier at the time of birth and noted that these were carried for the longest period of time during gestation. The lightest calves were dropped in the Spring, but calves born in Summer were from the shortest gestation periods. These differences were not statistically significant.

Breed

Fitch et al. (5) listed the following breed averages for birth weight in dairy cattle: Jersey, 57 pounds; Guernsey, 69 pounds, Ayrshire, 72 pounds; and Holstein, 91 pounds.

Littlewood (15) found that Ongole calves were heavier at birth than Sind or Kangayan calves in Indian cattle and believed that this difference was due to variation in length of gestation because the Ongole calves were carried three to four days longer than calves of the other breeds.

Burris and Blunn (1) reported average breed birth weights for the cattle included in their study as follows: Angus, 64.2 pouuds, Hereford, 67.4 pounds; and Shorthorn, 64.3 pounds. The difference between the Angus and Shorthorn breeds was not significant but that between the Shorthorn and Hereford breeds was.

Gerlaugh et al. (6) found that Herefords had significantly longer gestation periods than Angus cattle and that crossbreds were carried for an intermediate period of time.

Type

Woodward et al. (22) studied small and large types in Hereford cattle and found a significant difference in birth weight due to type.

Sire or Heritability of Birth Weight

Fitch et al. (5) noted differences in the birth weight of calves by different sires in dairy cattle; however, these were not significant.

Knapp et al. (10) observed differences between the birth weight of calves of the same sex by various bulls but stated that less than 10 per cent of the variance of birth weight was due to the influence of sire.

Piam (19) concluded that birth weight did not seem to be significantly influenced by the sire.

Dawson et al. (2) found a significant sire effect and estimated that 28.9 per cent of the variance in the uncorrected birth weights of calves was due to the influence of sires. Upon correction for age of dam and sex of calf, only 11 per cent of the variance in birth weight was found to be due to sires. This was not statistically significant.

Woodward and Clark (22) reported significant sire effects on the birth weight of Hereford calves.

The reason many experiments do not show significant sire effects on birth weight may be due to the uniformity of bulls tested. Eckles (3) concluded that the sire influence was small when the sire and dam were of the same breed although it was evident in the case of crossbreeding.

Dawson et al. (2) stated that even though there was no significant difference between sire groups, there was some trend of influence and it was possible that the effect of sires was expressed to a greater extent in the progeny of their daughters than in his own offspring.

Heritability may be defined as that portion of variance which is due to additive genetic factors. Some research workers have computed heritability estimates for birth weight in beef cattle.

Knapp and Nordskog (12) reported three estimates for the heritability of birth weight in cattle which were computed by different methods. These were as follows: half-sib correlation, 0.23; sire-offspring regression, 0.42; and sire-offspring regression within sire groups fed within the same year, 0.34.

Burris and Blunn (1) computed a heritability estimate for birth weight of 0.22 by the half-sib correlation method. This indicated a non-significant influence of sires on calf birth weight.

Effect of Dam, Repeatability of Cow's Records

The repeatability of birth weight refers to the greater similarity among the birth weights of the calves from the same cow than among birth weights of calves from different females in an entire herd.

Repeatability differs from heritability because it includes the genetic influence transmitted by the cow together with the effects of environmental factors constituted by the dam's body during embryonic development.

Knapp et al. (10) reported a highly significant difference between cows on the birth weight of calves of the same sex. This finding was attributed to two factors: the length of the gestation period and the physiological breeding capacity of the cows as exemplified by the skeletal size and abdominal capacity. They concluded that 19 per cent of the variance in birth weight could be attributed to the influence of dams.

Gregory et al. (7) reported low repeatability values for uncorrected birth weights, although these were increased upon correction for sex of calves. The computed correlation coefficients were as follows:

	Not adjusted	Adjusted for sex
(a) between 1st & 2nd calves	0.161	0.244
(b) between 1st & 3rd calves	0.206	0.212
(c) between 2nd & 3rd calves	0.067	0.114

The only significant correlation coefficient was that of 0.244 between the corrected birth weights of the second and first calves.

MATERIAL AND METHODS

Data obtained for this study were taken on the grade Hereford cattle herd maintained at the Fort Hays Branch Experiment Station, Fort Hays, Kansas. The original herd was established in 1907 and no females have been introduced into it since 1919. All replacement cows were bred and born at the Station since that year. The general management of the herd was based upon practices considered essential for good commercial production. Productive females have been retained as breeding animals as long as possible under these conditions.

Approximately 140 cows were included in the breeding herd each year and good quality purebred Hereford bulls were used for herd sires with the exception of four bulls that were produced in the herd and used for breeding purposes.

The Fort Hays herd was established to study the improvement obtained by the use of purebred bulls on a grade herd of cows and to evaluate the efficiency of various methods of selection.

The birth weight data used in this study were collected during the period from 1944 to 1952, inclusive. The age of the dams at the time of calving was known and birth dates were recorded. Birth weights were taken within 24 hours after parturition. Since 1946 the cows were weighed immediately after parturition. Records of the allotment of cows for breeding were maintained so the sires of all calves were known.

The breeding season was limited to the months of April, May, and June and the calving season occurred from the latter part of December until the middle of April.

Inbreeding was avoided in the herd and two-year-old heifers were generally mated to the youngest and smallest bull for the prevention of accidental injuries during breeding. With these two exceptions, the cows were allotted to the various bulls during the breeding season by restricted randomization on the basis of age as indicated by the cow numbers.

The feeding management of the herd may be divided into the grazing season from the latter part of April until the first of November and the winter feeding during the remainder of the year. The winter ration usually consisted of 25 to 30 pounds of sorghum silage, six pounds of alfalfa hay, and one pound of cottonseed cake. During dry seasons when grazing was limited, the cows usually lost weight from the middle of August until the first of November.

Calves were weaned the middle of October each year.

STATISTICAL ANALYSIS OF DATA

Most of the analyses made in this study were done according to methods described by Snedecor (20). The statistical analyses

Table 1. Mean birth weights ($\bar{y}$) of calves classified by years of birth, sexes, and sires (1944-1952), and mean weights ($\bar{x}$) of dams by years, sexes, and sires to which mated (1947-1952).

SIRES	1944 MALES N	1944 MALES $\bar{y}$	1944 FEMALES N	1944 FEMALES $\bar{y}$	1944 TOTAL N	1944 TOTAL $\bar{y}$	1945 MALES N	1945 MALES $\bar{y}$	1945 FEMALES N	1945 FEMALES $\bar{y}$	1945 TOTAL N	1945 TOTAL $\bar{y}$	1946 MALES N	1946 MALES $\bar{y}$	1946 FEMALES N	1946 FEMALES $\bar{y}$	1946 TOTAL N	1946 TOTAL $\bar{y}$
H	12	73.	13	67.	25	70.												
I	10	71.	8	68.	18	70.												
J	2	77.	2	74.	4	75.5	8	78.	17	72.5	25	74.5						
M	13	71.	11	68.5	24	70.	18	74.5	13	68.5	31	72.	12	69.5	5	67.	17	69.
N	13	72.5	10	70.5	23	71.5	14	71.5	12	72.	26	71.5	13	80.5	7	73.5	20	78.
O	12	73.5	9	73.5	21	73.5	12	74.5	9	75.5	21	75.	11	76.	8	77.5	19	76.5
P							2	65.	2	65.	4	65.	14	75.5	13	76.	27	75.5
Q													7	75.5	8	71.	15	73.5
TOTAL	62	72.5	53	69.5	115	71.	54	74.	53	71.5	107	73.	57	75.5	41	74.	98	75.

SIRES	1947 MALES N	1947 MALES $\bar{y}$	1947 MALES $\bar{x}$	1947 FEMALES N	1947 FEMALES $\bar{y}$	1947 FEMALES $\bar{x}$	1947 TOTAL N	1947 TOTAL $\bar{y}$	1947 TOTAL $\bar{x}$	1948 MALES N	1948 MALES $\bar{y}$	1948 MALES $\bar{x}$	1948 FEMALES N	1948 FEMALES $\bar{y}$	1948 FEMALES $\bar{x}$	1948 TOTAL N	1948 TOTAL $\bar{y}$	1948 TOTAL $\bar{x}$	1949 MALES N	1949 MALES $\bar{y}$	1949 MALES $\bar{x}$	1949 FEMALES N	1949 FEMALES $\bar{y}$	1949 FEMALES $\bar{x}$	1949 TOTAL N	1949 TOTAL $\bar{y}$	1949 TOTAL $\bar{x}$
M	19	79.	1,211	6	74.5	1,207	25	78.	1,210	12	77.	1,188	11	70.	1,150	23	73.5	1,170	22	77.	1,179	10	64.	1,170	32	73.	1,176
O	11	83.	1,253	10	80.	1,226	21	82.	1,240	10	81.	1,131	11	76.	1,207	21	78.5	1,171									
P	7	82.	1,181	14	74.	1,184	21	77.	1,183	14	79.	1,209	11	74.	1,176	25	76.5	1,194	12	77.5	1,100	12	70.5	1,083	24	74.	1,092
Q	10	80.	1,210	6	80.	1,303	16	80.	1,245																		
R	11	84.	1,132	6	79.5	1,136	17	82.	1,134																		
S	6	77.5	1,130	5	77.5	1,121	11	77.5	1,126																		
T	4	77.	1,136	2	67.	1,225	6	73.5	1,165	12	79.	1,171	4	73.	1,256	16	77.5	1,192									
U										15	76.	1,037	9	70.5	998	24	74.	1,022	6	77.5	1,149	16	71.	1,138	22	73.	1,141
V																			10	78.5	1,058	7	70.5	1,044	17	75.	1,052
W																			2	67.	1,095	2	60.5	1,005	4	64.	1,050
X																			7	83.	1,125	5	79.5	1,182	12	81.5	1,149
TOTAL	68	80.5	1,190	49	77.	1,199	117	79.	1,194	63	78.	1,144	46	73.	1,149	109	76.	1,146	59	78.	1,130	52	70.	1,118	111	74.	1,125

SIRES	1950 MALES N	1950 MALES $\bar{y}$	1950 MALES $\bar{x}$	1950 FEMALES N	1950 FEMALES $\bar{y}$	1950 FEMALES $\bar{x}$	1950 TOTAL N	1950 TOTAL $\bar{y}$	1950 TOTAL $\bar{x}$	1951 MALES N	1951 MALES $\bar{y}$	1951 MALES $\bar{x}$	1951 FEMALES N	1951 FEMALES $\bar{y}$	1951 FEMALES $\bar{x}$	1951 TOTAL N	1951 TOTAL $\bar{y}$	1951 TOTAL $\bar{x}$	1952 MALES N	1952 MALES $\bar{y}$	1952 MALES $\bar{x}$	1952 FEMALES N	1952 FEMALES $\bar{y}$	1952 FEMALES $\bar{x}$	1952 TOTAL N	1952 TOTAL $\bar{y}$	1952 TOTAL $\bar{x}$
P	15	79.5	1,209	10	70.	1,176	25	75.5	1,196	8	79.5	1,183	11	77.	1,228	19	78.	1,209									
U	13	72.5	1,190	12	69.	1,157	25	71.	1,174	15	83.5	1,196	5	72.5	1,087	20	80.5	1,169	11	77.	1,138	14	74.5	1,150	25	75.5	1,145
V	10	76.	1,208	12	76.	1,200	22	76.	1,204	9	79.5	1,172	10	80.	1,178	19	80.	1,175	17	79.	1,109	7	76.5	1,172	24	78.	1,127
W	11	75.	1,192	12	69.	1,181	23	72.	1,186	17	77.	1,180	5	72.5	1,225	22	76.	1,190	2	74.5	1,097	3	68.	1,173	5	70.	1,143
X	10	82.	1,200	12	73.	1,182	22	77.	1,189	10	80.5	1,092	10	77.5	1,170	20	79.	1,131	14	77.	1,098	10	75.5	1,019	24	76.5	1,065
Y	2	78.5	995	3	64.5	990	5	70.	992																		
Z										10	72.	1,030	13	65.	1,056	23	68.	1,045	9	73.	1,106	15	73.	1,119	24	73.	1,114
A																			11	74.	1,069	10	77.5	1,068	21	76.	1,069
TOTAL	61	77.	1,193	61	71.	1,170	122	74.	1,182	69	79.	1,148	54	74.	1,153	123	76.5	1,150	64	76.	1,103	59	74.5	1,110	123	75.5	1,107

TOTAL MALES N	TOTAL MALES $\bar{y}$	TOTAL FEMALES N	TOTAL FEMALES $\bar{y}$	TOTAL TOTAL N	TOTAL TOTAL $\bar{y}$	SIRES
12	73.	13	67.	25	70.	H
10	71.	8	68.	18	70.	I
10	78.	19	73.	29	74.5	J
96	75.	56	68.5	152	72.5	M
40	74.5	29	72.	69	73.5	N
56	77.5	47	76.5	103	77.	O
72	78.	73	73.5	145	76.	P
17	78.	14	75.	31	76.5	Q
11	84.	6	79.5	17	82.	R
6	77.5	5	77.5	11	77.5	S
16	78.5	6	71.	22	76.5	T
60	77.5	56	71.5	116	74.5	U
46	78.5	36	76.	82	77.5	V
32	75.5	22	69.	54	73.	W
41	80.	37	76.	78	78.	X
2	78.5	3	64.5	5	70.	Y
19	72.	28	69.	47	70.5	Z
11	74.	10	77.5	21	76.	A
557	77.	468	72.5	1025	75.	TOTAL

N : number of calves in each group.
$\bar{y}$: mean birth weight of calves in pounds, given at the nearest 0.5 pound.
$\bar{x}$: mean weight of dams in pounds, given at the nearest pound.

used were as follows: analysis of variance with multiple classification; block-within-block analysis of covariance; tests of the significance of simple linear regression coefficients, and of the difference between regression coefficients in groups; multiple regression analyses; and calculation of simple interclass and intraclass correlation coefficients.

The heritability estimate was computed by the half-sib correlation method as described by Fisher (4) and Heltzer et al. (8).

The data were taken in the Fort Hays cow herd which consisted of approximately 140 females of breeding age. From five to seven bulls were used as sires each year and the number of calves produced varied from 98 to 128 annually. The few sets of twins were discarded.

The data permitted studies of the influences of age and weight of dam, year, sex of calves, and sire on birth weights of calves. An estimation of heritability of birth weights and a computation of the repeatability of a cow's record have also been included.

The birth weight data used in the study are shown in Table 1. These are summarized according to year, sex, and sire. The average birth weights have been computed and the average weight of the dams is indicated for the six years during which the cows were weighed in the experiment.

Because of the volume of data and the large number of variables studied, it was deemed essential to conduct a preliminary study to provide a basis for more detailed analyses of the data.

This procedure appeared especially important because most of the sires were used during different years.

Preliminary Study

Sire, Year, and Sex of Calf. The data included two sets of three sires which were used during three consecutive years. Since a reasonable number of calves were sired each year by each of these six bulls and the cows appeared to have been allotted for breeding fairly equally in regard to age, an analysis of variance was computed for each of these two sets of data to study the influence of year, sex, sire, and interactions of these variables on the birth weight of the calves. In order to simplify calculations in the analysis by avoiding complicated computations because of unequal sub-class numbers, the analysis was based on the mean birth weight of sire groups of calves by sex and year.

The first group of calves studied was born in 1944, 1945, and 1946; the sires of these calves are designated as M, N, and O. The second group was born in 1949, 1950, and 1951, and their sires are designated as P, U, and X.

These two sets of data and the corresponding analyses of variance are shown in Tables 2 and 3. The second order interaction was used as the error term in testing the first order interactions.

The analysis of the first group of data showed significant sire x sex and sire x year interactions. The main effects (sex, sire, and yeqr) were tested against an error term which was obtained by pooling the mean squares of the significant first order interactions. The pooled error term has a value of 13 to 14.

Table 2 (a). Mean birth weights of calves ($\overline{y}$) of sires M, N, and O, by sex, for 1944, 1945, and 1946.

YEARS	SEX	SIRES – M N	M y	N N	N y	O N	O y	TOTAL N	TOTAL y
1944	males	13	71.15	13	72.38	12	73.42	38	216.95
	females	11	68.27	10	70.30	9	73.55	30	212.12
	total	24	139.42	23	142.68	21	146.97	68	429.07
1945	males	18	74.72	14	71.42	12	74.58	44	220.72
	females	13	68.46	12	72.08	9	75.55	34	216.09
	total	31	143.18	26	143.50	21	150.13	78	436.81
1946	males	12	69.58	13	80.38	11	75.91	36	225.87
	females	5	67.00	7	73.57	8	77.50	20	218.07
	total	17	136.58	20	153.95	19	153.41	56	443.94
Total		72	419.28	69	440.13	61	450.51	202	1,309.82
Total for males		43	215.45	40	224.18	35	223.91	118	663.54
Total for females		29	203.75	29	215.95	26	226.60	84	646.28

N: number of calves.
y: mean birth weights in pounds.

Table 2 (b). Analysis of variance based on mean birth weights of calves by three sires, by sex, and in each of three years.

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	
Years	2	18.44	9.22	NS
Sires	2	74.90	37.45	NS
Sexes	1	16.55	16.55	NS
Years X Sires	4	52.37	13.09	*
Years X Sexes	2	1.05	0.53	NS
Sires X Sexes	2	28.90	14.45	*
Years X Sires X Sexes	4	7.87	1.97	
Total	17			
Error	184	1,367.87	7.43	
Total	201			

NS non significant
* significant at the 5 % level.

Since the F values must be equal to 6.39 with two and four degrees of freedom and to 6.94 with four and four degrees of freedom, to be significant at the 5 per cent level the main effects are not significant.

The significant interactions indicate that year, sire, and sex influence the birth weight of calves; thus the main effects were present but inconsistent.

The significant sire x sex interaction indicates that bulls tend to sire calves differing in birth weight because of sex and that the sex influence is different among sires. Table 2 shows that bulls M and N consistently sired heavier male than female calves during the three years studied whereas bull O sired slightly heavier females than males during the same period. It is interesting to note that upon the inclusion of the calves sired by bull O during 1947 and 1948 for a total of five years it was found that the average birth weight of his bull calves was 77.5 pounds and that for his heifers 76.5 pounds. This suggests that the sire x sex interaction obtained in this analysis might be due to sampling error because the five-year mean should be more reliable than that for three years. It is also possible that weight and age of dam, which were not considered in the analysis, might have caused some interference.

The significant sire x year interaction indicates that effect of sires upon the birth weight of their calves varies in different years. An explanation of this finding is difficult; however, the age and weight of both sires and dams change with years; one or more of these factors might be responsible, since the analysis did

Table 3 (a). Mean birth weights of calves ($\bar{y}$) of sires P, U, and X, by sex, for 1949, 1950, and 1951.

YEARS	SEXES	P N	P y	U N	U y	X N	X y	TOTAL N	TOTAL y
1949	males	12	77.58	6	77.67	7	83.14	25	238.39
	females	12	70.58	16	71.19	5	79.60	33	221.37
	total	24	148.16	22	148.86	12	162.74	58	459.76
1950	males	15	79.40	13	72.46	10	81.90	38	233.76
	females	10	69.80	12	69.17	12	73.25	34	212.22
	total	25	149.20	25	141.63	22	155.15	72	445.98
1951	males	8	79.37	15	83.47	10	80.60	33	243.44
	females	11	77.00	5	72.40	10	77.60	26	227.00
	total	19	156.37	20	155.87	20	158.20	59	470.44
Total		68	453.35	67	446.36	54	476.09	189	1,376.18
Total for males		35	236.35	34	233.60	27	245.64	96	715.59
Total for females		33	217.38	33	212.76	27	230.45	93	660.59

N: number of calves.
y: mean birth weights in pounds.

Table 3 (b). Analysis of variance based on mean birth weights of calves by three sires, by sex, and in each of three years.

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	
Years	2	50.625	25.31	NS
Sires	2	79.90	39.95	NS
Sexes	1	168.06	168.06	*
Years X Sires	4	34.64	8.66	NS
Years X Sexes	2	2.10	1.05	NS
Sires X Sexes	2	2.76	1.38	NS
Years X Sires X Sexes	4	36.33	9.08	
Total	17			
Error	171	2,163.61	12.65	
Total	188			

NS non significant
* significant at the 5 % level.

not permit an estimation of the separate effect of these.

The results of the analysis of the second set of data are not in agreement with those obtained in the first analysis of a comparable set of data. The first order interactions in the second analysis were all non-significant, and the mean square of the second order interaction was used to test the main effects. The effects of year and sire were found to be non-significant; however, the effect of sex was significant. The significant sex effect is in agreement with most previous studies. These also show a tendency for males to be heavier at birth than females. The non-significant difference between sires due to the relatively small difference of sires on the birth weight of their progeny as found in previous studies or to marked similarity of the sires included in the study. It is also possible that the sire differences were overshadowed or cancelled by effects due to dams.

The error terms at the bottoms of Tables 2 and 3 in both analyses of variance were computed from the real birth weights of the calves instead of from averages of sire groups. The error terms were large in both cases which is an indication that these analyses leave a rather large portion of the variance unexplained. One probable cause for the large error terms is that the allotment of cows to different bulls was far from perfectly at random.

<u>Age of Dam</u>. A series of graphs plotting birth weight on age of dam were made to determine whether or not there was a ten-

dency for birth weight to be influenced by the age of the dam. It was concluded that all sire groups within sex and year had too few dam-calf couples to indicate a definite trend, so pooled graphs were made. Two graphs were drawn for all calves of each sex born in 1950 and two additional graphs were prepared for the male and female progeny of sire P over the six-year period (1945-1951). It was noted that three-year-old heifers tended to produce the lightest calves at time of birth of all the dam age groups considered. The birth weight of calves tended to increase with the age of dam until an age of five years, at which time the graphs leveled off to form a plateau until 10 to 11 years of age.

The calves produced by cows 13 and 14 years of age tended to be somewhat lighter than those produced by younger mature cows. The birth weights were scattered over a rather large range in each age group of dams studied, so it was concluded that these data should be analyzed to determine whether or not the observed trend was statistically significant.

The two sets of data contained in Tables 2 and 3 were used for the computation of the regression of birth weight of calf on age of dam. These analyses are presented in Tables 4 and 5.

The individual regression coefficients were found to be quite different, varying from -0.788 to -0.47 in the first set of data and from -0.689 to 0.647 in the second set of data; however, these regression coefficients were not significantly different from each other and not significantly different from zero in either set of data.

Table 4 (a). Simple regression coefficients (b) of birth weight of calf on age of dam, within sexes for sires M, N, and O.

SIRES	MALES		FEMALES -	
	N	b	N	b
M	43	-0.038	29	0.393
N	40	-0.788	29	0.045
O	35	0.0007	26	0.473

Table 4 (b). Test of significance of the difference between individual regression coefficients.

SOURCE OF VARIATION	D/F	ERRORS OF ESTIMATE		
		SUM OF SQUARES	MEAN SQUARES	
Deviations from average regression within sire groups by sex.	195	15,144.114	77.66	
Deviations from individual group regressions.	190	14,836.899	78.09	
Differences among group regressions.	5	304.002	60.80	NS

D/F degrees of freedom.
NS non significant.

Pooled regression coefficient: -0.0897

test of significance of pooled b: t: -0.4 Non Significant

Table 5 (a). Simple regression coefficients (b) of birth weight of calf on age of dam, within sexes for sires P, U, and X.

SIRES	MALES		FEMALES	
	N	b	N	b
P	35	-0.347	33	0.144
U	34	0.563	33	0.587
X	27	-0.689	27	0.647

Table 5 (b). Test of significance of the difference between individual regression coefficients.

SOURCE OF VARIATION	D/F	ERRORS OF ESTIMATE		
		SUM OF SQUARES	MEAN SQUARES	
Deviations from average regression within sire groups by sex.	182	13,504.112	74.19	
Deviations from individual group regressions.	177	13,085.273	73.93	
Differences among group regressions.	5	418.839	83.77	NS

D/F degrees of freedom.
NS non significant.

Pooled regression coefficient: 0.0792

test of significance of pooled b: t: 0.370 Non Significant.

Table 6 (a). Simple regression coefficients of birth weight of calf on weight of dam, within sexes for sires P, and U.

SIRES	MALES		FEMALES	
	N	b	N	b
P	35	0.042 *	33	0.0276 *
U	34	0.012 NS	33	0.0147 NS

* significant at the 5 % level.
NS non significant.

Table 6 (b). Test of significance of the difference between individual regression coefficients.

SOURCE OF VARIANCE	D/F	ERRORS OF ESTIMATE	
		SUM OF SQUARES	MEAN SQUARES
Deviations from average regression within sire groups by sex.	130	8,665.725	66.66
Deviations from individual group regression.	127	8,466.011	66.66
Differences among group regressions.	3	199.714	66.57 NS

D/F degrees of freedom.
NS non significant.

Pooled regression coefficient: 0.0221

test of significance of pooled b: t: 3.25 Highly significant.

These findings may be due to the fact that the Fort Hays data did not include calving records of two-year-old heifers and was composed predominantly of records of cows from four to eight years of age. The proportion of heifers and old cows was consistently small and it is likely that these data did not permit a good estimation of the effect of age of dam on birth weight of calves. The analyses indicate that age of dam does not appear to influence the brith weight of calves significantly.

Weight of Dam Immediately after Parturition. The weight of the dams was taken within 24 hours after calving during the last six years of the Fort Hays experiment. The progeny which sires P and U produced during 1949, 1950, and 1951 were used to study the effect of weight of dam on the birth weight of calves. The analyses of the data as shown in Table 6 were made by computing regression coefficients of birth weight on weight of dams for calves of the same sex. The four individual regression coefficients did not differ greatly from each other and were all positive, indicating that heavier cows tend to produce heavier calves. The individual regression coefficients did not differ significantly and the pooled coefficient was 0.22 which is highly significant, meaning that for each 100 pounds increase in weight of dams, the weight of calves was increased approximately two pounds on the average. The weight of dams included in this study varied from 870 to 1595 pounds. This difference was not as large as that for the total data in which the cows varied in weight from 850 to 1665 pounds.

Age and Weight of Dam. The results of the preceding studies indicated that age of dam had no significant influence on birth weight of calves whereas weight of dam had a significant effect. Since animals increase in body weight until maturity, there may be a relationship between age and weight of dams. It was concluded that a multiple regression analysis of birth weight of calves within sires and sexes on age and weight of dam should be computed to estimate the independent effects of these two factors.

The data used in this study consisted of the records of sires P and U for 1949, 1950, and 1951.

Table 7 gives the eight partial regression coefficients of birth weight of calf on weight and age of dam within sex of calves. The analyses compared the results of simple and partial regression coefficients of birth weight on weight and age of dam. Table 8 shows the test of significance of the information obtained in addition to the simple linear regression of birth weight of calves on weight of dams by taking into account the age of cows in a multiple regression study and vice-versa.

The role of age of dam in the multiple regression of birth weight on age and weight of dam as well as the simple linear regression of birth weight on age of dam were never significant; however, the role of weight of dam in the same multiple regression was significant or highly significant two times out of four. The same was true for the simple linear regression of birth weight of calf on weight of dam. This finding indicates that there is a marked effect of weight of cow on birth weight of calves in certain instances and that there is a tendency for heavier cows to produce heavier calves at time of birth.

Table 7. Partial regression coefficient (b_1) of birth weight of calf on weight of dam and partial regression coefficient (b_2) of birth weight of calf on age of dam. Coefficients computed within sex, with all calves sired by bulls P and U over the period 1949-1951.

SIRES	SEXES	N	b_1	b_2
P	males	35	0.0478	-0.698
	females	33	0.0284	-0.102
U	males	34	0.00857	0.464
	females	33	0.00835	0.465

N: number of calves

Table 8. Information additional to linear regression of birth weight of calf on weight of dam brought by taking into account age of dam, and vice-versa.

SIRE GROUPS	N	b_w	b_wSx_1y	b_a	b_aSx_2y	b_1	b_2	$b_1Sx_1y + b_2Sx_2y$
P males	35	.0420	518.196	-.347	39.578	.0478	-.698	669.37
P females	33	.0276	257.086	.144	6.113	.0284	-.102	268.87
U males	34	.0117	72.998	.563	98.790	.0086	.464	134.89
U females	33	.0147	63.878	.587	97.015	.0084	.465	113.14

b_w : Simple regression coefficient of birth weight of calf on weight of dam.
b_a : Simple regression coefficient of birth weight on age of dam.
b_1 : Partial regression coefficient of birth weight on weight of dam.
b_2 : Partial regression coefficient of birth weight on age of dam.
Y : Birth weight of calf.
X_1 : Weight of dam.
X_2 : Age of dam.

SOURCE OF VARIANCE	MALES D/F	MALES MEAN SQUARES		SIRES	FEMALES D/F	FEMALES MEAN SQUARES	
				P			
Linear X_1	1	518.196	*		1	257.086	*
Additional due to X_2	1	151.17	NS		1	11.78	NS
Remainder	32	72.71			30	40.45	
Total	34				32		
				U			
Linear X_1	1	72.10	NS		1	63.88	NS
Additional due to X_2	1	61.89	NS		1	49.25	NS
Remainder	31	120.43			30	30.62	
Total	33				32		
				P			
Linear X_2	1	39.58	NS		1	6.11	NS
Additional due to X_1	1	629.79	**		1	262.75	*
Remainder	32	72.71			30	40.45	
Total	34				32		
				U			
Linear X_2	1	98.79	NS		1	97.01	NS
Additional due to X_1	1	36.10	NS		1	16.12	NS
Remainder	31	120.43			30	30.62	
Total	33				32		

NS non significant.
* significant at the 5 % level.
** significant at the 1 % level.

General Study of the Effects of Sire, Sex of Calves, and Year of Birth

It was concluded that age of dam had no significant effect on birth weight of calves on the basis of the preliminary studies of this factor, so it was ignored in the general study of the Fort Hays data. Weight of dam was found to have a significant effect, and since a record of weight of dams at time of calving was maintained in the project over a six-year period (1947 to 1952), the data for this period were used in the general study of factors affecting birth weight of calves.

These data were analyzed on the basis of year, sex, and sire. Only those sire groups with at least ten calves of both sexes per year were used in the study. This included progeny from 13 different bulls which represented 32 sire groups not considering sex of calves or 64 sire groups of males and females. The number of offspring in each sire group within sex and year are shown in Table 9. The weight of dam was held constant by means of a covariance analysis which is summarized in Table 10.

The computed F values revealed highly significant differences. The birth weights of calves of the same sex and born in the same year but by different sires were significantly different ($P<0.01$), indicating a definite effect of sire on the birth weight of calves. The other computations were difficult to interpret; however, these indicate that sex (over all sires) and years (over all sires and both sexes) were responsible for highly significant differences in the birth weights of calves.

The regression coefficients of birth weight of calf on

Table 9. Number of calves within each sire group included in the general study of the effects of sire, sex, and year on birth weights of calves.

YEARS	1947			1948			1949			1950			1951			1952			TOTAL		
SEXES	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
SIRES																					
M	19	6	25	12	11	23	22	10	32										53	27	80
O	11	10	21	10	11	21													21	21	42
P	7	14	21	14	11	25	12	12	24	15	10	25	8	11	19				56	58	114
Q	10	6	16																10	6	16
R	11	6	17																11	6	17
S	6	5	11																6	5	11
T				12	4	16													12	4	16
U				15	9	24	6	16	22	13	12	25	15	5	20	11	14	25	60	56	116
V							10	7	17	10	12	22	9	10	19	17	7	24	46	36	82
W										11	12	23	17	5	22				28	17	45
X							7	5	12	10	12	22	10	10	20	14	10	24	41	37	78
Z													10	13	23	9	15	24	19	28	47
A																11	10	21	11	10	21
TOTAL	64	47	111	63	46	109	57	50	107	59	58	117	69	54	123	62	56	118	374	311	685

M: males
F: females
T: total.

Table 10. Block within analysis of covariance.

SOURCE OF VARIANCE	D/F	Sx^2	Sxy	Sy^2	$\frac{(Sxy)^2}{Sx^2}$	D/F	SS of error of estimate	Mean Square	F
Total	684	9,375,081.2	75,195.62	50,445.442	603.13	683	49,842.31		
Between years	5	704,491.1	13,674.72	1,908.041		5	1,741.42	348.28	4.91**
Within years	679	8,670,590.1	61,520.90	48,537.401	436.51	678	48,100.89	70.94	
Bet. sexes w. years	6	16,840.9	3,158.12	4,349.272		6	4,306.37	717.73	11.0**
With. sexes w. years	673	8,653,749.2	58,362.78	44,188.129	393.61	672	43,794.52	65.17	
Bet.sires w. sexes w. years	52	1,698,181.3	36,439.64	16,839.269		52	16,514.76	317.59	7.22**
Wit.sires w. sexes w. years	621	6,955,567.8	21,923.14	27,348.860	69.10	620	27,279.96	44.00	

X: weight of dam
y: birth weight of calf
** highly significant (1 % level).
SS: sum of squares.

weight of dam appeared to be significantly different from zero in the preliminary study; it was decided that these coefficients should be computed for the data used in the general study to determine whether or not the covariance analysis was justified. The computed regression and correlation coefficients were as follows:

	b	r	
(1) total	0.0080	0.1089	*
(2) within years	0.0071	0.096	*
(3) within sexes within years	0.0067	0.094	*
(4) within sires, within sexes within years	0.0031	0.050	NS

* Statistically significant at the 5 per cent level.
NS Non-significant.

These regression and correlation coefficients, even where significant, are smaller than those computed on the smaller sample used in the preliminary study. The analysis of the total data indicated a significant trend of variation of birth weight of calves with weight of dam. The pronounced decrease in the value of the preceding coefficients in the order listed, which finally reach non-significance within sires, within sexes within years, probably is due to the increasingly smaller groups into which the data were divided for their computation. This procedure undoubtedly made the general trend less apparent as reflected in the smaller coefficient values.

The largest regression coefficient computed was 0.008 on 685 calves and their dams. This means that on the average there was an increase of 0.8 pound in weight of calves at birth for an increase of 100 pounds in the weight of dams. The general study indicated weight of dam to be of less importance than the preliminary study.

The block-within-block analysis of variance of weights of dams, a part of the covariance analysis presented in Table 10, gives an indication of the repartition of cows in the different groups in regard to weight. The computed F values were as follows:

	F	
between years	11.03	**
between sexes within years	0.218	NS
between sires, within sexes within years	2.92	**

** Highly significant.
NS Non-significant.

The highly significant difference in weight of dams between years was probably due to variation in the composition of the herd from year to year or to variation in the condition of the cows at time of calving.

The non-significant difference in weight of dams between sexes indicated that weight of dam had no influence on sex of calves produced, which should be expected.

The highly significant difference in weight of dams between sire groups meant that the cows were not equally allotted in regard to weight after calving to the various bulls included in the study.

Estimation of Heritability of Birth Weight

A heritability estimate was computed on the birth weight of calves included in the general study. The half-sib correlation method was used and is shown in Table 11.

The heritability estimate of 149.16 per cent was surprisingly high, although the explanation given by Lush (17) for this method

Table 11. Computation of heritability estimate of birth weight by half-sib correlation.

SOURCE OF VARIANCE	COMPOSITION OF MEAN SQUARES	MEAN SQUARES
Between sires, within sexes, within years.	$\sigma^2 + \bar{K}\sigma^2_s$	317.59
Within sires, within sexes, within years.	σ^2	44.00

σ^2 : Error variance or variance between calves of the same sex, born in the same year, and by the same sire.

σ^2_s : Additional variance between calves of the same sex, born in the same year, but by different sires.

$\bar{k}$: Average number of calves of the same sex, by sire groups, by year.

Intrasire correlation: I $\dfrac{\sigma^2_s}{\sigma^2_s + \sigma^2}$

Heritability estimate: h^2 4 x I

$\bar{k}$ was computed by using the formula proposed by Dickerson (8).

$$\bar{k} \quad \frac{S\left(\frac{Sk^2}{Sk}\right)_c - S\left(\frac{Sk^2}{Sk}\right)_g}{N_c - N_g}$$

k : Number of observations in a set which has identical variance from the source concerned.

N_g : Number of groups with two or more subclasses each.

N_c : Total number of subclasses in N_g groups.

In the computation, N_c was the number of groups by sires, within sexes, within years.

N_g was the number of groups of calves, within sexes, within years.

:/.

Table 11. (Concl.)

N_c	: 64
N_g	: 12
$\bar{k}$	: 10.457
σ^2	: 44.00
σ_s^2	: 26.16
I	: 37.29 %
h^2	: 149.16 %

of computation accounts for this high value. Lush states:

> Unfortunately, the covariance between half-sibs has to be multiplied by four in order to reach an estimate of heritability because the correlation between their genic values is expected to be only one-fourth. This multiplication by four magnifies any sampling errors which may be in the estimate. It also magnifies any errors that may have been in estimating and discounting the environmental component.... In many sets of data, each sire has many offspring: if we consider each pair of these offspring by itself, the number of different half-sib relationships appears to be enormous. Yet where the same sire is responsible for the paternal sibship over and over again, the data do not really contain as much information as appears at first sight. The paternal half-sib correlation is merely a way of expressing how much smaller the variance is between paternal half-sibs than between sibs. Its statistical reliability depends in considerable part upon the number of different sires represented.

Repeatability Study of Birth Weight of Calves

A repeatability study was made to determine whether or not birth weights of calves produced by the same cow were more closely related with each other than with the birth weights of calves produced by different cows in the same herd.

Data used in this study were confined to dams having calving records at three years of age with a total of four to five calving records during successive years. A total of 35 qualifying cows had five calving records and 16 additional cows had four. The dams were classified by year of first calving and by sex of calves within these years. The separation of dams according to year of first calving and sex of calves is shown in Table 12.

A block-within-block analysis of variance was computed on the total 239 calving records of these 51 cows. A summary of the

Table 12. Number of calves of each sex, according to the year of first calving of the various dams.

1944				1945				1946				1947				1948				1949				
C	M	F	T	C	M	F	T	C	M	F	T	C	M	F	T	C	M	F	T	C	M	F	T	TOTAL
113	3	2	5	202	2	3	5	325	2	3	5	402	2	3	5	520	2	3	5	616	3	1	4	
124	3	2	5	210	1	4	5	334	2	3	5	410	1	4	5	546	3	2	5	620	3	1	4	
145	3	2	5	288	3	1	4	365	3	2	5	420	3	2	5	558	3	2	5	628	1	3	4	
160	5	0	5	214	3	1	4	371	4	1	5	437	2	3	5	567	3	2	5	637	4	0	4	
165	5	0	5	290	2	3	5	390	4	1	5	445	3	2	5	526	2	3	5	674	2	2	4	
176	4	1	5	235	3	1	4					457	3	2	5	530	3	2	5	675	1	3	4	
181	4	1	5									471	2	3	5	597	4	1	5	690	0	4	4	
130	4	0	4									477	4	1	5	5001	3	2	5	691	1	3	4	
												478	1	4	5	5002	2	3	5					
												4016	3	2	5	508	2	2	4					
												455	1	4	5	528	2	2	4					
																534	3	1	4					
																552	2	2	4					
TOTAL	31	8	39		14	13	27		15	10	25		25	30	55		34	27	61		15	17	32	239

Total number of males 134
Total number of females 105

C: cow's tag number
M: number of male calves
F: number of female calves
T: total number of calves.

Table 13. Analysis of variance of the birth weights of 239 calves by 51 cows, calving for the first time in six different years.

SOURCE OF VARIANCE	Degrees of Freedom	Mean Squares	F
Total	238		
Between cow groups by year of first calving.	5	302.465	3.78 **
Within cow groups by year of first calving.	233	79.92	
Between sexes within cow groups.	6	181.704	2.35 *
Within sexes within cow groups.	227	77.23	
Between cows within sexes within cow groups.	85	77.38	1.003 NS
Within cows within sexes within cow groups.	142	77.14	

NS statistically non significant

* significant at the .05 level

** significant at the .01 level.

analysis is presented in Table 13.

The analysis indicated a highly significant difference between years. The discrepancy in the birth weights of calves of groups of dams calving the first time in different years may have been caused by variation in the genetic composition of the cow herd among the groups of dams, by direct effects of years, or by the effects of the different sires.

There was also a significant difference in birth weights due to the sex of calves; however, the variance between progeny of the same dams was not significantly smaller than the variance between cow groups within sexes of calves within years. This last finding could be interpreted as an absence of repeatability of the birth weight of calves, although the very small number of calves in each of the groups considered may not have permitted a significant difference to be obtained in the analysis. It should also be noted that the form of analysis used is rather inefficient and may not show significant differences due to treatment as would more refined analyses.

Repeatability was estimated by correlation studies to determine whether or not there was a relationship between the birth weight of the first calf and the birth weights of succeeding calves.

Data used in this study were similar to those used in the preceding analysis of variance. Because of the significant effect of sex found in the previous analysis, it was decided that a correction for sex was necessary. The difference between average birth weights of the male and female calves within age of dam

Table 14. Average birth weights of male and female calves, within age of dams.

AGE OF DAMS (years)	MALE CALVES N	MALE CALVES $\bar{y}_m$	FEMALE CALVES N	FEMALE CALVES $\bar{y}_f$	DIFF. $\bar{y}_m - \bar{y}_f$
3	38	71.47	33	67.82	3.65
4	38	76.79	33	72.67	4.12
5	41	76.59	30	76.73	-0.14
6	30	79.83	21	72.09	7.74

$\bar{Y}_m$: Average birth weights of male calves.

$\bar{y}_f$: Average birth weights of female calves.

Birth weights are given in pounds.

N : Number of calves.

was used as a correction factor by adding it to the birth weight of the female calves. Table 14 shows the computation of these correction factors.

Corrections of this type introduce a definite bias. The birth weights of heifer calves of each dam were corrected on the basis of the average birth weight of calves from all dams. This procedure tends to cancel the effect of dam in the correlation between the birth weight of her calves.

Correlation coefficient between the birth weights of first and second calves was computed on the records of 71 dams which produced at least three successive calves, the first of which was at three years of age. The correlation coefficient was 0.1605, which was statistically non-significant ($^{r}0.05$ equals 0.232 with 70 degrees of freedom).

The correlation coefficient between the birth weight of the first calf and the average birth weight of second, third, and fourth calves was computed on the records of the 51 cows which had calving records at three, four, five, and six years of age. The coefficient was 0.30477, which is statistically significant ($^{r}0.05$ equals 0.273 with 50 degrees of freedom), meaning that birth weight of the first calf is partially indicative of the birth weights of all other calves produced by a dam.

SUMMARY AND CONCLUSIONS

A study was made of some of the factors affecting the birth weight of grade Hereford calves produced at the Fort Hays Branch Experiment Station, Hays, Kansas. These data were collected during the nine-year period, 1944 to 1952, and included more than 1000 calves.

Sire, birth weight, birth date, sex, and age of dam were known for all calves and weight of dam after parturition was known from 1947 to 1952.

The birth weights of all calves ranged from 45 to 110 pounds and averaged 75 pounds. The age of dams at time of calving varied from 3 to 14 years and the weight of cows immediately after parturition varied from 850 to 1665 pounds.

Preliminary studies were made on two fractions of the data. The influence of year of birth, sex, and sire on the birth weight of calves and interactions were considered in the analyses of variance of the two sets of data. The results were inconsistent and with the exception of sex in the second analysis, the main effects were not significant.

Age of dam had no significant effect on birth weight of calves whereas weight of dam appeared to have a significant influence. The simple regression coefficient of birth weight of calf on weight of dam computed on the records of two sire groups produced during three consecutive years was 0.0221.

A general study of the effects of sire, sex and year of birth was made on the birth weights of 685 calves born during the six-year period, 1947 to 1952. Weight of dam was held constant by analysis of covariance. The block-within-block form of analysis indicated highly significant differences between sires, between sexes over sires and between years over sires and sexes.

A heritability estimate of birth weight of calf was computed by intrasire correlation within sexes within years; the result was 149.16 per cent.

A study of repeatability of cow's record was made on the birth weights of calves from dams which produced three, four, or five calves in consecutive years, the first offspring having been produced at three years of age.

Cows were classified by year of first parturition. A block-within-block analysis of variance did not show a significant reduction of variance of birth weights among calves from the same cow as compared to calves from different dams.

Correlation coefficients were computed between the successive records of the same cow, birth weight having been corrected for sex of calf. The correlation coefficient between birth weights of the first and second calves computed on the records of 71 cows was not significant; however, the correlation coefficient between the birth weight of the first calf and the average birth weight of the second, third, and fourth calves was 0.305. It was statistically significant. This result indicated that the birth weight of the first calf of a cow did not give a good indication of her second calving's record, although it was slightly related to the whole production of the dam.

In conclusion, birth weight did not seem to be significantly influenced by age of dam, the first calving occurring at three years of age.

Weight of cow seemed to influence significantly birth weight of calf as shown by studies of part of the data, but the regression coefficient of birth weight on weight of dam computed by sire groups, by sex and year over the whole data was not significant.

Sire effects were significant only considering the whole data. It could be concluded that, in the case of the Fort Hays herd, a difference between sires with regard to the birth weight of their calves was shown only by studying together a large number of sires, each one having a large number of offspring each year.

The methods of analysis used in this study brought up the problem of experimentation in the field of Animal Husbandry. Because of the nature of experiments, sires being used in different years and each sire having an unequal number of progeny in each sex, more complex methods of analysis would be necessary to obtain more information.

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SOME FACTORS AFFECTING BIRTH WEIGHT OF BEEF CALVES

by

HUGUETTE M. TSATSKIN

Ingenieur Agronome,
Institut National Agronomique, Paris, France, 1952

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The birth weight of an animal is an expression of its prenatal development, and many research workers have found that the birth weights of beef calves are related to postnatal growth and feedlot performance.

Birth weights have usually been considered in beef cattle progeny tests and have become of special interest because of their relationship to the economic characters. The birth weight of calves can be obtained quite easily by most purebred breeders and since it is one of the first available measurements in the animal's life, an application of birth weight considerations in breeding techniques may prove expeditious to cattle breeding improvement.

Many previous studies have been made to determine the factors affecting the birth weights of beef calves; some of these studies have also included estimations of the heritability of birth weight.

A study was made of some of the factors affecting the birth weight of grade Hereford calves produced at the Fort Hays Branch Experiment Station, Hays, Kansas. The data were collected during the nine year period, 1944 to 1952, and included 1025 calves.

Sire, birth weight, birth date, sex, and age of dam were known for all calves and weight of dam after parturition was known from 1947 to 1952.

The birth weights of all calves averaged 75 pounds.

Preliminary studies were made on fractions of the data. The influence of year of birth, sex, sire, and their interactions, age and weight of dam were considered. Age of dam did not seem to have any influence on birth weight, whereas weight of dam appeared to have a significant influence. Other factors gave inconsistent results.

A general study of the effects of sire, sex, and year of birth was made on the birth weights of 685 calves. Weight of dam was held constant by covariance analysis. The block-within-block form of analysis indicated highly significant differences between sires, between sexes over sires, and between years over sires and sexes.

A heritability estimate of birth weight of calf was computed by intrasire correlation within sexes within years; the result was 149.16 percent.

Studies of repeatability of cow's record were made.

Dams were classified by year of first calving. A block-within-block analysis of variance did not show a significant reduction of variance of birth weights among calves from the same cow as compared to calves from different dams.

Correlation coefficients were computed between the successive records of the same cow, birth weights having been corrected for sex. The correlation coefficient between the birth weights of the first and second calves was not significantly different from zero; however, the correlation coefficient between the birth weight of the first calf and the average birth weight of the second, third, and fourth calves was 0.304. It was statistically significant. Thus, first calving's record seemed to be slightly related to the following records of the dam.

In conclusion, the birth weights of calves did not seem to be significantly influenced by age of dam when the first calving occurred at three years of age. Weight of dam seemed to significantly influence birth weight as shown in studies of parts of the data, but the regression coefficient of birth weight on weight of dam computed by sire group, by sex and year over the whole data was not significant.

Sire effects were significant only in the analysis of the whole data. In the case of the Fort Hays herd, it could be concluded that a difference between sires in regard to the birth weight of their progeny would be shown only by studying a large number of sires each having a large number of offspring each year.

The methods of analysis used in this study bring up the problem of experimentation in the field of Animal Husbandry. Because of the nature of breeding experiments, (sires being used in different years, and having unequal numbers of progeny of each sex), more complex methods of analysis would be necessary to obtain more information.