STUDIES ON FACTORS IN BEEF CATTLE PRODUCTION IN A SUBTROPICAL ENVIRONMENT
1. BIRTH WEIGHT

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SUMMARY

Data from 502 calves from 244 cows during the years 1954-1957 at "Brian Pastures" Pasture Research Station of the Queensland Department of Agriculture and Stock were analysed. The effects of sex, year of birth, age of dam, weight of dam and time of birth on birth weight were evaluated.

The mean birth weight of all calves was 70·4 lb. The male calves weighed 4·7 lb. more than the female calves, the difference being significant. Significant year differences were recorded due to the marked lowering of birth weight following the 1957 drought. First-calf heifers gave birth to calves which were 4 lb. lighter than those of mature cows.

Weight of dam was significantly related to birth weight and was associated with approximately 6 per cent. of the variation in birth weight of the calf. Time of calving, in a 3-month calving period, also was significantly related to birth weight but was only associated with 3 per cent. of the variation in the birth weight of the calf.

The repeatability of birth weight was 0·25 and that of weight of dam was 0·86.

I. INTRODUCTION

Beef cattle production in Queensland is carried on under a wide variety of seasonal conditions, but in most cases beef cattle are produced entirely on unimproved pasture. Since little supplementary feeding is practised, the growth rate of the livestock is somewhat seasonal, being largely influenced by the quality and the quantity of pasture available. The seasonal nature of this growth curve has been discussed and various methods of making growth more continuous have been suggested (Chester 1952; Alexander and Chester 1956; Shelton 1956; and Sutherland 1959).

This is the first of a series of papers in which the growth of the beef animal is considered at certain strategic periods in its life, and the influence of the various relevant factors evaluated.

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II. EXPERIMENTAL PROCEDURE

The study recorded here was based on the birth weights of 502 calves from 244 cows during the years 1954 to 1957, inclusive, at "Brian Pastures," in south-eastern Queensland. This station is owned by the Australian Meat Board and operated by the Queensland Department of Agriculture and Stock as a pasture research station with special reference to beef cattle. It is situated on the western bank of Barambah Creek, about 10 miles from Gayndah in latitude 25° 40′S. The average rainfall of the district is about 29 in., and the rainfall is mainly of summer incidence. The property consists of ridges of varying slopes and broken areas of levee bank and flood plain regions along the creeks. The vegetation was originally an open eucalypt forest and the pasture grasses are now mainly *Heteropogon contortus* (black spear grass) and a number of blue grasses (species of *Dichanthium* and *Bothriochloa*).

Marked seasonal fluctuations in the growth rate of cattle have been reported on this property by Alexander and Chester (1956) and Sutherland (1959). The calving season usually extended over approximately 10 weeks from late October to early January. The ages of the cows at the birth of all the calves were known. The cows were either Hereford or Poll Hereford cows mated to Poll Hereford bulls. Each of the breeder paddocks was ridden over daily during the calving season and all newborn calves were caught, numbered, weighed and identified with their dam as described by Burns and Alexander (1956).

The relation of birth weight to sex of calf, year of birth, age of dam, weight of dam and time of birth was studied.

The data were analysed by statistical procedures as described by Snedecor (1958) and Anderson and Bancroft (1952). A preliminary analysis indicated that (1) interactions were unimportant and (2) regressions could be regarded as homogeneous from year to year. An additive linear model was therefore fitted by least squares, constants being fitted for years, sex, first-calf heifers *v.* adult cows, and cows.

Variates considered were the birth weight of the calf and the weight of the dam in the May previous to calving. The latter was used as it was considered indicative of the size of the cow and because the weights immediately prior to and following calving were not available.

III. REVIEW OF LITERATURE

(a) Sex

Bull calves have been consistently reported to be significantly heavier than heifer calves. Dairy bull calves have averaged 4·8 lb heavier than heifer calves (Eckles 1919; McCandlish 1922; Fitch, McGilliard, and Drum 1924; Knapp, Lambert, and Black 1940; Tyler, Chapman, and Dickerson 1947; and Braude and Walker 1949).

In the beef breeds, the sex difference appears to be of a similar order. Knapp, Baker, Quesenberry, and Clark (1942) found that Hereford male calves at the Miles City Range Livestock Experiment Station in Montana for the period 1926–1940 averaged 5·8 lb heavier at birth than females. Dawson, Phillips, and Black (1947) compared the birth weights of bull and heifer calves from the Shorthorn herd at Beltsville, Maryland, and found that male calves averaged 4·2 lb heavier than females when their birth weights were adjusted to the basis of 6-year-old dams. Gregory, Blunn, and Baker (1950), studying Hereford calves at two Nebraska experiment stations, showed that the males averaged 5 lb and 4 lb more at birth than the female calves. Burris and Blunn (1952) examined the birth weights of Aberdeen Angus, Hereford and Shorthorn cattle. Males of the three breeds averaged 5·3, 4·5 and 4·9 lb respectively heavier at birth than females. In a study by Botkin and Whatley (1953), Hereford male calves were 4·4 lb heavier than females at birth. Koch and Clark (1955), using records of 5,952 Hereford calves at the Miles City Range Livestock Experiment Station, showed bull calves to average 5·6 lb heavier at birth than female calves. In a more recent and more comprehensive examination of the Miles City data, Clark, Shelby, Quesenberry, Woodward, and Willson (1958) found that birth weights differed between sexes, males averaging 5 lb heavier than females.

(b) Year Differences

In almost every investigation made of factors affecting birth weight of calves, significant year differences due to drought years have been reported. Knapp *et al.* (1942) demonstrated that birth weight varied relatively little from year to year except in years following drought. However, Burris and Blunn (1952) found that year differences were not significant. Clark *et al.* (1958) found birth weight to vary considerably among years. It decreased after a year of extreme drought or after an extremely severe winter. In general, birth weight seemed to be little affected by environmental conditions unless they were extremely severe.

(c) Age of Dam

Age of the dam has an influence on the birth weight of the calf. Calves from 2-year-old cows were found by Knapp *et al.* (1942) to be about 10 lb lighter than those from mature cows, while the change in age of the cow had little effect on birth weight after four years of age. Burris and Blunn (1952), in a study of Aberdeen Angus, Hereford and Shorthorn cattle, found calves from 2–3-year-old cows to average 4·7, 4.9 and 6.0 lb lighter at birth than calves from 4–5-year-old cows and calves from 3–4-year-old cows to average 3·0, 1·3 and 1·9 lb lighter than those from 4–5-year-old cows. Birth weight reached its maximum when cows of the Aberdeen Angus, Hereford and Shorthorn breeds, respectively, were 10–11, 11–12 and 10–11 years old. Rollins and Guilbert (1954) showed that the effect of age of dam was smaller for female than for male calves. Koch and Clark (1955),

using Hereford cattle, computed factors for adjusting birth weight to a mature-dam basis. Calves from 3-year-old and 4-year-old cows were 4 and 2 lb lighter than those from mature cows, while calves from 10-year-old cows were 2 lb lighter than those from cows aged between five and nine years, inclusive. Clark *et al.* (1958) reported similar findings with Hereford calves. Age of dam had an effect on the birth weight of calves from 3-year-old cows as compared with calves from older cows but otherwise was of little importance in relation to birth weight. Male and female calves from 3-year-old cows averaged 4 lb lighter at birth than those from 5–10-year-old cows. Male and female calves from 4-year-old cows averaged 1 and 2 lb lighter respectively than those from the older class.

(d) Weight of Dam

Since the weight of the dam is closely related to the age of the dam, studies evaluating this factor have been made when age has been held constant. A correlation of + ·26 was found between birth weight of calf and previous-fall weight of dam by Knapp *et al.* (1942). Gregory *et al.* (1950) calculated a correlation of + 0·21 between birth weight and cow weight after calving at one station and of + 0·32 between birth weight and cow weight on the last weigh day prior to calving at the second station from which they drew their data. Dawson *et al.* (1947) examined the relative influences of weight of dam and age of dam on birth weight of the calf and found them to be approximately equally related to birth weight. The multiple correlation coefficient between both age and weight of dam with birth weight was 0·56, or very little higher than the respective simple correlations (r = ·45 and ·49).

(e) Time of Birth

The season of birth influences the birth weight of the calf indirectly through the nutritional plane of the dam. In most studies, the calving period is quite short, so this influence is minimized. Koch and Clark (1955) examined this effect with a calving period of two months and found that calves born later in the calving season were slightly heavier at birth. They attributed this difference to better pasture conditions or possibly to a weight difference caused by variation in gestation lengths of cows. J. W. Riley, of the Queensland Department of Agriculture and Stock (unpublished data 1959), has demonstrated the important influence of adverse maternal nutrition in depressing the birth weight of the calf. Davenport and Neil (1958) found only a slight difference between the birth weights of calves born in February–March and those born in May. The difference between the uncorrected birth weights of the calves in the two groups was 3 lb in favour of the calves born in May.

IV. RESULTS AND DISCUSSION

The uncorrected average birth weights of the calves in the four years of this study were 71·6, 70·2, 74·1 and 65·3 lb (Table 1). When a correction was applied for age of dam and sex, the overall mean birth weight was 70·4 lb. This is one of the same order as the birth weights of Hereford calves reported in the literature. Dawson *et al.* (1947) recorded an overall average of 70·1 lb for Hereford calves. Nelms and Bogart (1956) reported mean birth weights for three lines of Hereford cattle of 65–73 lb. Koch and Clark (1955) reported an overall mean of 75·6 lb and Clark *et al.* (1958) an average birth weight of 76 lb.

(a) Sex

The sex difference of 4·7 lb in favour of the male calves, after correcting for age of dam, was significant at the 1 per cent. level. This sex difference is of similar order to those reported in the literature. Some attempts have been made to explain the reason for this sex difference. Knapp *et al.* (1940) considered that differences in length of gestation period account for 25–35 per cent. of the variation in birth weight between sexes. Dawson *et al.* (1947) found that the gestation length of male calves was slightly longer than that of female calves.

(b) Year Differences

The year differences were significant at the 1 per cent. level. An examination of the average birth weights within years indicates that there was little change in the average birth weight during the first three years, but during the fourth year there was a marked difference, the average for the calves born in

Table 1

MEAN UNCORRECTED BIRTH WEIGHTS OF THE CALVES, AGES OF DAMS AT CALVING AND WEIGHTS OF THE DAMS IN THE MONTH OF MAY PRIOR TO CALVING

	Year				
	1954	1955	1956	1957	All Years
Average birth weight (lb)—					
Males	73·5	73·4	76·0	67·6	72·8
Females	66·9	66·0	72·0	62·7	67·4
All calves	71·6	70·2	74·1	65·3	70·4
Age of dam at calving (year) ..	4·8	5·5	6·1	5·9	5·6
Weight of dam in the May prior to calving (lb)	878	944	948	842	909
Rainfall (in.)	38·07	36·05	55·84	9·11	..

the 1957 calving season being 5·1 lb less than the overall mean. This was due to 1957 being a drought year, when the pregnant cows were on an extremely low plane of nutrition (Table 1). This is in agreement with results reported by Knapp *et al.* (1942), Burris and Blunn (1952), and Clark *et al.* (1958), who found

that birth weight varied relatively little from year to year except following drought. However, while the birth weights of the calves varied from year to year, the effect of the various other factors influencing birth weight did not differ between years.

(c) Age of Dam

Because of the small number of animals involved in this study (Table 2) and because a search of the literature revealed that only calves from first-calf heifers had significantly lower birth weights than calves from mature cows, the only comparison made was between first-calf heifers and mature cows. In this herd, the heifers were mated at about two years so that they were approximately

Table 2

DISTRIBUTION OF CALVES OF BOTH SEXES FROM COWS OF EACH AGE GROUP WITHIN EACH YEAR

Year	Sex	No. of Calves for Each Category of Age of Dam in Years							
		3	4	5	6	7	8	9	10
1954	Male	5	34	13	4	7	..	..	..
	Female	2	31	15	5	8	2	1	..
1955	Male	6	5	36	15	5	10	1	..
	Female	11	0	28	17	6	7	3	1
1956	Male	11	7	2	27	17	3	8	2
	Female	7	6	3	26	14	5	6	..
1957	Male	13	5	7	2	27	5	3	2
	Female	12	10	3	1	16	10	2	1

three years old when they calved. This may account to some extent for the lack of significance in the difference of 4·03 lb between the birth weights recorded from cows of the two classes (Table 3). The relationship between birth weight and age of dam within years is presented graphically in Figure 1.

Table 3

ESTIMATES OF THE MEAN BIRTH WEIGHTS OF ALL CALVES AND THE EFFECTS OF THE FACTORS CONSIDERED WITH THEIR 95 PER CENT. CONFIDENCE LIMITS

—	Effect	95% Confidence Limits
Mean birth weight of all calves (corrected for age of dam) (lb) ..	70·1 ± 9·6*	
Sex effect (male-female) (lb) ..	4·66	2·59 to 6·73
Age of dam effect (adult-first calf) (lb)	4·03	−0·36 to 8·42
Weaning age (days)	182 ± 17·5*	

* Standard deviation.

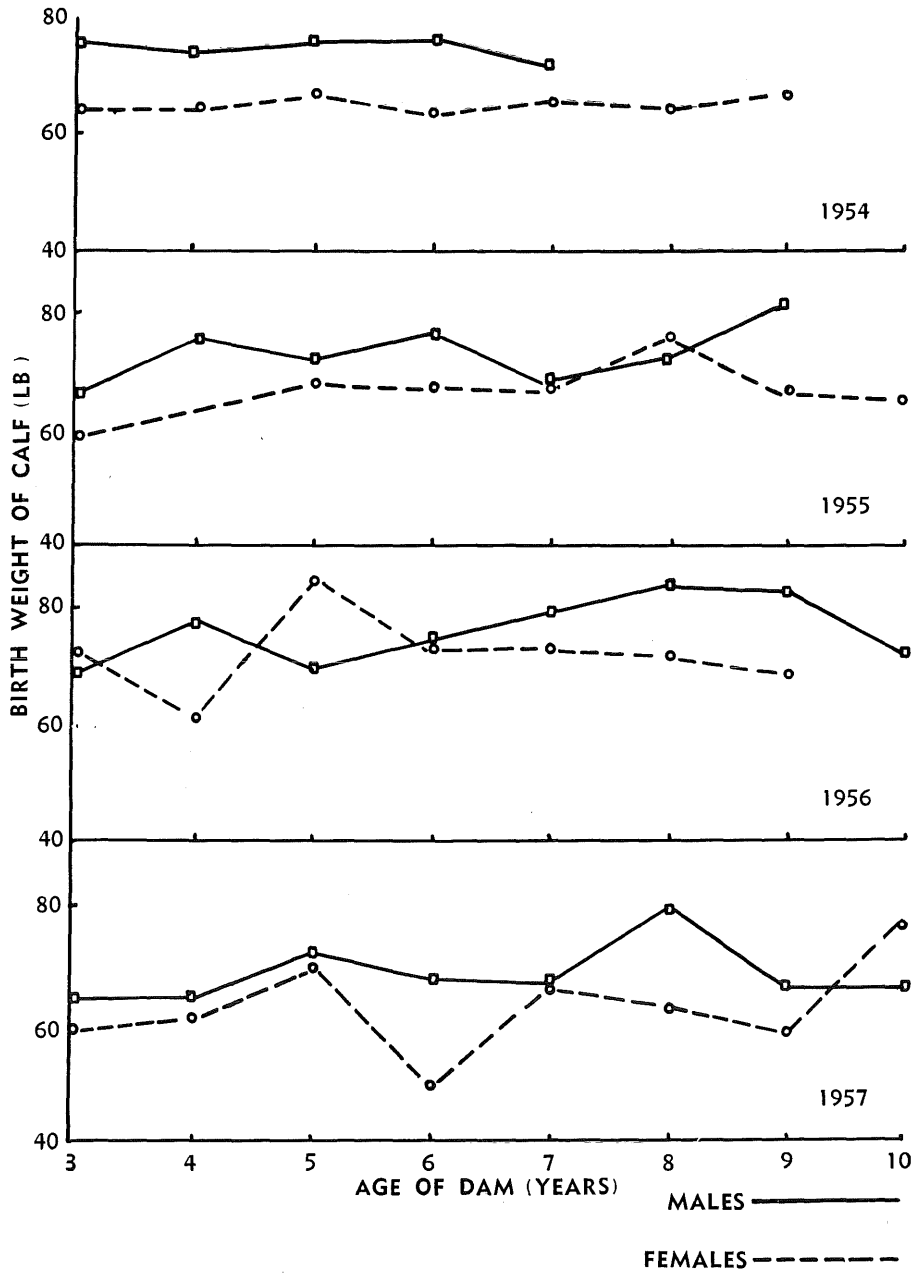

Fig. 1.—Birth weights of calves from each age group of cows in each year.

(d) Weight of Dam

Since the body weight of the dam is closely related to the age of the dam, this aspect was examined graphically (Figure 2). There appeared to be a positive association between weight of dam and age of dam up till nine years of age, after which there were too few animals to draw any definite conclusions (Table 2). The weight of the cow in May previous to calving was selected because it has been shown that May represents the end of the growing season on this property. It was considered that this was the time when all animals would be in uniformly

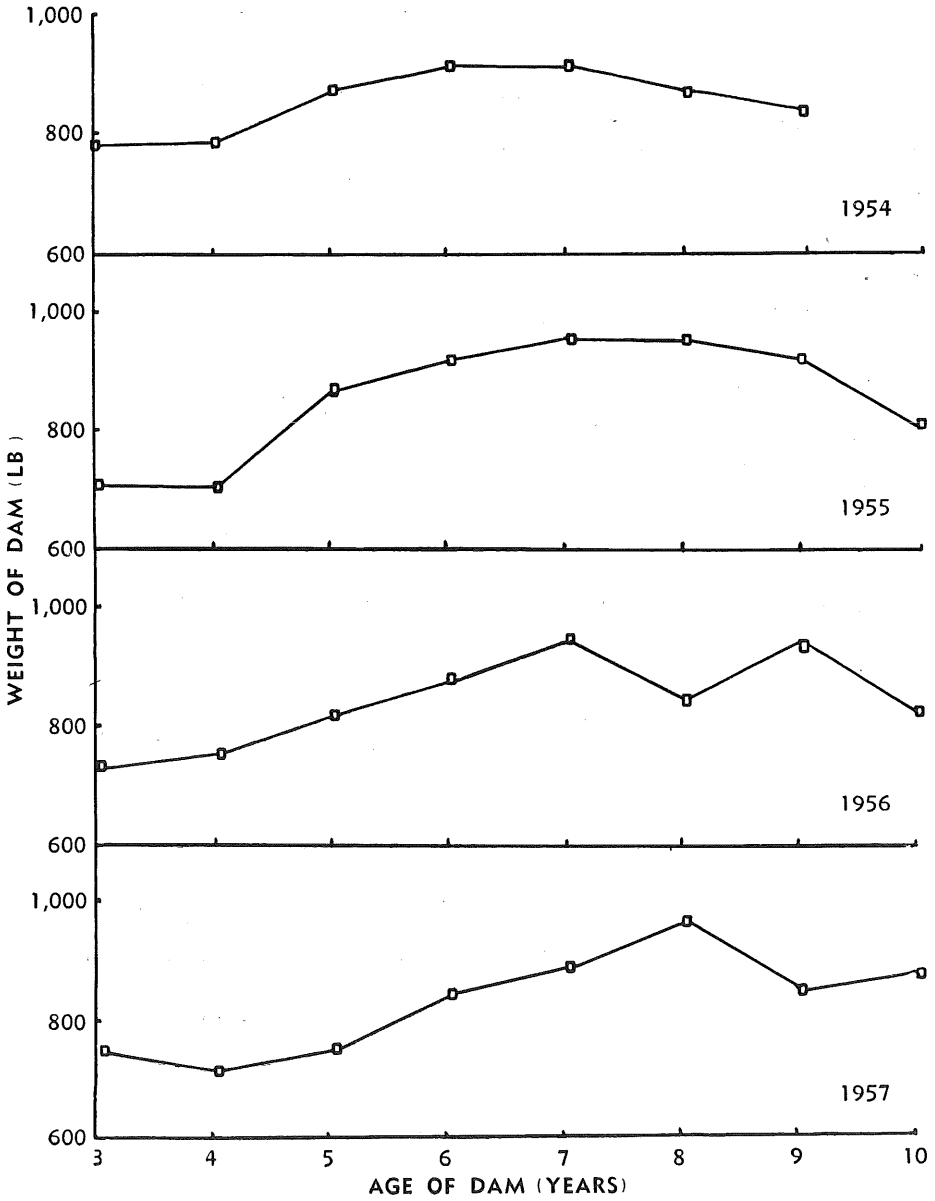

Fig. 2.—Average weights of cows at various ages in each year.

good condition, pregnant cows being not more than four months advanced in pregnancy and lactating cows having sufficient pasture to meet the demands of their calves and maintain condition. The May weight was as close an approximation as possible of the characteristic weight of the dam, which Mason (1951) considered to be the important factor influencing birth weight rather than the cow's condition or state of nutrition, as demonstrated in the 1957–58 calving.

A correlation of 0·24 was found between the birth weight of the calf and the May weight of the dam, indicating that approximately 6 per cent. of the variation in birth weight was associated with the weight of the dam (Table 4). The regression of birth weight on weight of dam indicated that for each 100 lb increase in body-weight of the dam there was a corresponding 1·9 lb increase in

Table 4

CORRELATION AND REGRESSION CO-EFFICIENTS BETWEEN BIRTH WEIGHT, WEIGHT OF DAM AND WEANING AGE OF CALF

—	Correlation Coefficient	Regression Coefficient and Standard Error
Birth weight on Weight of dam ..	0·24**	0·019 ± 0·005
Birth weight on Weaning age ..	−0·18**	−0·096 ± 0·034
Birth weight on Weight of dam (weaning age held constant) ..	+0·26**	0·021 ± 0·005

** Significant at the 1 per cent. level.

birth weight of the calf. This association of birth weight with weight of the dam is of a similar order to that reported in the literature (Knapp *et al.* 1942; Gregory *et al.* 1950; and Dawson *et al.* 1947). When time of calving was held constant the correlation between birth weight and weight of dam was increased to 0·26, which was only slightly greater than that when time of calving was ignored.

(e) Time of Birth

Since the calving occurred over a short period of less than three months it was not anticipated that there would be any large influence of time of calving on birth weight of the calf. At weaning time, all the calves were weaned on the same day, so the effect of time of birth was studied by the regression of birth weight on age at weaning. This regression was negative and significant, which meant that calves born towards the end of the period were heavier than those born earlier (Table 4). On the average the birth weight increased ·96 lb for each 10 days during the calving season. Thus over the 10 weeks' calving period there was an overall average increase in birth weight of 6·7 lb. This effect, however, was only slight, as indicated by the size of the correlation coefficient ($r = 0·18$) between birth weight and weaning age. Only 3 per cent. of the variation in birth weight was due to time of calving, compared with 6 per cent. for weight of dam. The slight improvement in the correlation between weight of dam and birth weight when time of calving was held constant indicates that there was little association between body-weight of the cow and the time of calving.

(f) Repeatability

Repeatability of traits can be defined as the proportion of the variance among cows each with one record which is due to permanent differences among the cows. It can also be regarded as the correlation between repeated records by the same individual. Repeatability is needed when comparing the producing abilities of animals which have different numbers of records. Traits such as birth weight occur only once in an animal's lifetime and are repeatable only when considered as a characteristic of the cow. Since a cow influences the calf both by the genes transmitted and by the maternal environment she provides from birth to weaning, the correlation between calves from the same cow includes a component due to genetic likeness of half-sibs, a component from the maternal environment, and any gene-environment interactions. Thus the repeatability may be regarded as an upper limit for the heritability of the trait. In this analysis, sire effects have been ignored, and it is reasonable to expect that sire differences would have a bearing since sire influences have been reported in the literature (Dawson *et al.* 1947; Eckles 1919; and Knapp and Nordskog 1946).

The repeatabilities or intra-class correlations are shown in Table 5. The repeatabilities of birth weight and weight of dam are significant at the 1 per cent. level while that of weaning age is just significant at the 5 per cent. level. Of these, the repeatability of weight of dam is of a sufficient order to be useful. It would indicate that selection of dams for body weight could be quite effective. However, the repeatability of birth weight is not sufficiently large to suggest that the prediction of the birth weight of a calf from a certain cow would be accurate.

Table 5

REPEATABILITY (INTRA–CLASS CORRELATION) OF THE BIRTH WEIGHT, WEANING AGE AND WEIGHT OF THE COW

——	Repeatability	95% Confidence Limits
Birth weight	0·25**	0·12 to 0·36
Weaning age	0·13*	0·00 to 0·25
Weight of dam	0·86**	0·83 to 0·89

* Significant at the 5 per cent. level.
** Significant at the 1 per cent. level.

V. CONCLUSIONS

In general, it can be seen that the birth weight of calves is influenced by both genetic and environmental influences. Certain of the environmental influences have been assessed and some have been found to have a fairly large influence on the birth weight of the calf. The repeatability of birth weight has been determined in order to obtain some indication of the possible genetic influences on the birth weight of the calf. These would appear to be rather low and of a similar order to those recorded in the literature. The calculation of repeatability ignoring sire effects was resorted to rather than heritability since less than half of the herd is mated in single-bull mating paddocks in any one year. The determination of heritability would mean the discarding of over half the data and the consequent low numbers used would not give reliable heritability estimates.

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REFERENCES

ALEXANDER, G. I., and CHESTER, R. D. (1956).—Growth studies of beef cattle in Queensland. *Qd J. Agric. Sci.* 13:69-95.

ANDERSON, R. L., and BANCROFT, T. A. (1952).—"Statistical Theory in Research". (McGraw-Hill: New York).

BOTKIN, M. P., and WHATLEY, J. A., Jnr. (1953).—Repeatability of production in range beef cows. *J. Anim. Sci.* 12:552-60.

BRANDE, R., and WALKER, D. M. (1949).—Mortality, weight and body measurements at birth of dairy shorthorn calves. *J. Agric. Sci.* 39:156-163.

BURNS, M. A., and ALEXANDER, G. I. (1956).—The growth rate of beef calves at "Brian Pastures", Central Burnett District. *Qd Agric. J.* 82:505-8.

BURRIS, M. J., and BLUNN, C. T. (1952).—Some factors affecting gestation length and birth weight of beef cattle. *J. Anim. Sci.* 11:34-41.

CHESTER, R. D. (1952).—Some problems of beef cattle production. *Aust. Vet. J.* 28:273-87.

CLARK, R. T., SHELBY, C. E., QUESENBERRY, J. R., WOODWARD, R. R., and WILLSON, F. S. (1958).—Production factors in range cattle under northern Great Plains conditions. U.S. Dep. Agric. Tech. Bull. No. 1181.

DAVENPORT, N., and NEIL, H. G. (1958).—Late summer and autumn calving for beef production. *J. Dep. Agric. W. Aust.* 7:409-13.

DAWSON, W. M., PHILLIPS, R. W., and BLACK, W. H. (1947).—Birth weight as a criterion of selection in beef cattle. *J. Anim. Sci.* 6:247-57.

ECKLES, C. H. (1919).—A study of the birth weight of calves. Mo. Agric. Exp. Sta. Res. Bull. No. 35.

FITCH, J. B., MCGILLIARD, P. C., and DRUM, G. M. (1924).—A study of the birth weights and gestation of dairy animals. *J. Dairy Sci.* 7:222-33.

GREGORY, K. E., BLUNN, C. T., and BAKER, M. L. (1950).—A study of some of the factors influencing the birth and weaning weights of beef calves. *J. Anim. Sci.* 9:338-46.

KNAPP, B., Jr., BAKER, A. L., QUESENBERRY, J. R., and CLARK, R. T. (1942).—Growth and production factors in range cattle. Mont. Agric. Exp. Sta. Bull. No. 400.

KNAPP, B., Jr., LAMBERT, W. V., and BLACK, W. H. (1940).—Factors influencing length of gestation and birth weight in cattle. *J. Agric. Res.* 61:277-85.

KNAPP, B. Jr., and NORDSKOG, A. W. (1946).—Heritability of growth and efficiency in beef cattle. *J. Anim Sci.* 5:62-70.

KOCH, R. M., and CLARK, R. T. (1955).—Influence of sex, season of birth and age of dam on economic traits in range beef cattle. *J. Anim. Sci.* 14:386-97.

MASON, I. L. (1951).—Performance recording in beef cattle. *Anim. Breed. Abst.* 19:1-24.

MCCANDLISH, A. C. (1922).—Studies in the growth and nutrition of dairy calves. *J. Dairy Sci.* 5:301-20.

NELMS, G. E., and BOGART, R. (1956).—The effect of birth weight, age of dam and time of birth on suckling gains of beef calves. *J. Anim. Sci.* 15:662-6.

ROLLINS, W. C., and GUILBERT, H. R. (1954).—Factors affecting the growth of beef calves during the suckling period. *J. Anim. Sci.* 13:517-27.

SHELTON, J. N. (1956).—The performance of beef cattle in North Queensland. *Proc. Aust. Soc. Anim. Prod.* 1:130-7.

SNEDECOR, G. W. (1958).—"Statistical Methods". 5th Ed. (Iowa State College Press: Ames.)

SUTHERLAND, D. N. (1959).—Factors affecting the performance of beef cattle on unimproved pastures in Queensland. *Aust. Vet. J.* 35:129-34.

TYLER, W. J., CHAPMAN, A. B., and DICKERSON, G. E. (1947).—Sources of variation in the birth weight of Holstein-Friesian calves. *J. Dairy Sci.* 30:483-98.

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