SOME FACTORS AFFECTING DIFFICULTY AT PARTURITION OF TWO-YEAR-OLD HEREFORD HEIFERS

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CHAPTER I

INTRODUCTION

Range cattlemen have generally followed the practice of breeding heifers to calve for the first time at three years of age. Beef heifers can, however, be bred at fifteen or sixteen months of age in order to calve as two-year-olds. If all other factors were equal, the practice of calving heifers at two years of age would be economically more desirable than calving them for the first time at an older age for two reasons. The first of these is that calving a heifer at two years of age requires her maintenance as a non-producer for a shorter period of time. The second reason for calving a heifer at two years of age is that her total lifetime production may be greater than that of a heifer which drops her first calf as a three-year-old. This is because the two-year-old will have more years in which to produce if both females are culled at the same age. Because replacement costs are an important component of total operating costs of a ranching enterprise, a cow which can produce an extra calf during her time in the herd will be more profitable.

However, the practice of calving heifers at three rather than at two years of age is widely accepted, because it is assumed that all factors other than age are not equal. Several serious disadvantages have been attributed to calving heifers at two years of age. Conception rates are said to be low if heifers are bred at sixteen months of age; heifers bred to calve at two sometimes may fail to rebreed the following season; growth of the heifers may be permanently stunted; and their first calves are usually light in weight at weaning time. However, the most serious disadvantage of calving at two years of age seems to be difficulty at parturition and death losses of the calves and their dams. Some reports indicate that about fifteen per cent of the calves and three per cent of the cows may be lost even where calving is carefully supervised. This disadvantage, when coupled with the others, is often regarded as sufficient to make the calving of heifers at two years of age a practice of questionable value.

The reason given for difficulty of calving in two-year-old heifers is the immaturity and lack of skeletal size in the heifers with insufficient corresponding reduction in the sizes of the calves at birth. That is, the calves are simply too large to traverse the heifers' birth canals. Therefore, it seems reasonable that calving difficulty could be reduced either by increasing the size of the heifers or by decreasing the birth weights of the calves.

The purposes of this study were to determine to what extent calving difficulty could be alleviated by breeding only the larger heifers to calve as twos, and to determine whether difficulty at parturition could be reduced by the proper choice of the bulls to which the heifers were bred. Since most studies have shown that the heritability of birth weight is moderately high, and that birth weight and size at maturity are correlated, it was thought that the selection of small sires should reduce the birth weights of their calves and reduce calving difficulty. To test this hypothesis sires of small, medium, and large types were used in the study. Because calves by Angus sires are generally lighter at birth than are calves by Hereford sires, it was decided to use both Hereford and Angus sires even though only Hereford heifers were to be used. The primary objectives, as listed previously, were to determine the effect that the sires had upon calving difficulty through (and possibly apart from) their effect upon birth weights, and to determine the effect of the sizes of the heifers upon difficulty at parturition. However, it was also possible to investigate the difference in degree of difficulty at birth attributable to differences between bull calves and heifer calves from two-year-old heifers.

CHAPTER II

REVIEW OF LITERATURE

As was mentioned in the introduction, it has generally been assumed that there are disadvantages to breeding heifers to calve at two years of age. Snapp (1952) did not believe that calving heifers at two could be generally recommended. He stated that lactation would seriously stunt the future growth of two-year-old heifers. He also stated that heifers bred to calve at two might become temporarily barren, and that there would be heavy death losses of heifers and calves at parturition. Ensminger (1951) also stated that heifers calving at two years of age often suffered from retarded growth and temporary barrenness; their calf crops were sometimes small and death losses at calving were often high. Ensminger said there appeared to be an increasing tendency toward early calving, but he recommended that as a general practice heifers should not be calved at less than thirty months of age. Guilbert and Hart (1952) made the above general objections to two-year-old calving, and they added that permanent damage to the genital tracts of heifers might result from calving them at too young an age. Anonymous (1951) stated that breeding heifers to calve at two caused the difficulties previously listed.

Williams (1943) also mentioned that two-year-old calving would result in lower conception rates the following year.

Withycombe (1930) found that heifers calving for the first time at two years of age had 15.6 per cent smaller calf crops at three years of age and 13.9 per cent smaller calf crops when four years old than did heifers calving for the first time at three years of age. There was no difference in calf crop percentage when the cows were five years old or older. When both the two and the three year old groups were six years of age, the group which had calved for the first time at two had weaned an average of 0.7 more calves per cow than the other group. At six years of age the cows which had calved at two had also yielded $35.35 more net profit per cow than those which had calved for the first time at three. The mature body weights of those heifers calved at two averaged 100 pounds less than the weights of those heifers calved first at three, but this difference did not affect calving performance.

Warren (1950) analyzed 402 conceptions in beef cows and found that two-year-old cows were harder to settle than were three-year-olds. Two-year-old cows required 2.04 services per conception, while three-year-olds required 1.71. No yearlings were involved in the study. Similar results had been reported by Lasley <u>et al</u>. (1943) who found fertility lowest in two and three year old cows and highest in those five or six years old.

However, Baker and Quesenberry (1944), working with range beef cows, were unable to show any definite association of fertility with age of cow. There was at least an apparent difference in amount of difficulty of birth, for 4.5 per cent of the calves from three-year-old cows were born dead while only 3.4 per cent of the calves from cows of all ages were born dead.

Bennett et al. (1949) conducted a four year test of the effects of calving heifers at two years of age. They found that calving at two did not reduce conception rates in the following years. In fact the heifers which calved at two had, at the end of the test, produced 1.03 more calves per cow than those which calved for the first time at three. At maturity the cows which calved at two weighed only eight pounds less than those which calved for the first time at three. Bennett also reported that calving difficulties were very common among heifers which calved at two and that several calves died at birth.

Anonymous (1954) stated that of 60 Hereford yearlings bred to an Angus bull 53 weaned calves. The heifers rebred without trouble and were not stunted in growth. There was some trouble at calving, which resulted in the loss of one heifer and six calves. Albaugh and Strong (1953) summarized 2,195 parturitions of two-year-old heifers on California ranches. They found that 2.1 per cent of the cows and 15.6 per cent of the calves died during parturition. Nineteen per cent of the heifers exposed to bulls did not calve, and only 67 per cent of the heifers exposed weaned calves. Pope et al. (1955) have, at the end of six years of study on the effect of level of wintering and age at first calving upon lifetime performance, found no detrimental effects upon lifetime performance due to two-year-old calving. However, 43 per cent of the heifers which calved at two years of age had to be helped in the delivery of their first calves, while only 4.6 per cent of the heifers which calved first at three years of age required help in calving. There was an 11 per cent death loss of calves from heifers calved at two and a 3.5 per cent loss of the two-year-old heifers.

Despite the general cautions against calving heifers at two years of age, it appears that the actual extent of detrimental effects is uncertain. This is particularly true with regard to conception rate and future growth or performance of the heifer. Nearly all authors have pointed out that serious calving difficulty can be expected when heifers are bred as yearlings.

Many ranchers are evidently willing to accept the risks of calving difficulties and death losses which result from two-year-old calving, for a survey of management practices conducted by Ensminger et al. (1955) revealed that half the cattlemen interviewed breed 80 per cent or more of their heifers to calve as two year olds. Another fourth of the cattlemen surveyed breed up to 20 per cent of their heifers as yearlings. Since so many ranchers are evidently following the practice of breeding heifers as yearlings, it is highly desirable that methods be found which will reduce the death losses resulting from the practice of calving heifers at two.

As stated in the introduction, the reason most commonly given for difficulty of calving in two-year-old heifers is lack of skeletal size in the heifers with little reduction in the birth weights of their calves (Anonymous, 1951; Guilbert and Hart, 1952; Anonymous, 1954; and Albaugh and Strong, 1953). If the birth weight of the calf could somehow be reduced, and if the size of the heifer could be increased, much calving trouble might be eliminated.

Most studies of factors affecting birth weights center about the influences of nutrition, size of dam, age of dam, breed, size, and type of sire, and sex of calf. Since birth weights cannot ordinarily be taken immediately after the calf is dropped, there is a possibility of error in determining birth weight due to some calves being several minutes and others several hours old at the time they are weighed. However, Koch et al. (1955) found this to be unimportant. They stated that 163 calves weighed at birth and at both 12 and 24 hours after birth gained an average of only 0.4 of a pound during the first twelve hours and 0.8 of a pound during the second twelve hours.

Eckles (1916) stated that the nutrients required to develop a calf were so minute in comparison with the maintenance requirements of the cow, that the weight of the calf at birth was not influenced by the ration received by the dam during gestation. This statement received partial confirmation by Woodward _et al_. (1942) who found a difference of 7.7 pounds between the birth weights of calves classified as large type and those classified as small type, but who found no differences due to full-feeding versus limited-feeding within the type classifications. They concluded that birth weights were determined by the type of the sire and dam of the calf to a much greater extent than by level of nutrition of the dam. Woolfolk and Knapp (1949) found no differences among the birth weights of calves whose dams had been maintained on pastures classified as lightly, moderately, and heavily stocked.

However, other workers have reported an apparent effect of nutrition of the dams upon the birth weights of their calves. Knapp _et al_. (1942) stated that although the skeletal size of the dam had a much greater effect on the birth weight of her calf than did the amount of flesh she was carrying, there did seem to be a reduction in the birth weights of calves in years following severe drought. That is, when range conditions were poor during gestation the birth weights of calves were smaller. Black _et al_. (1938) found that beef cows wintered on range with a cottonseed cake supplement dropped calves which weighed two pounds more at birth than the calves of cows wintered without a supplement. Five separate trials yielded nearly identical results which indicated that the difference was probably real. A similar study conducted by Stanley (1938) revealed a five pound average difference in birth weights between calves from cows fed a protein supplement and calves from cows fed no protein supplement. There were no differences in birth weights attributable to various mineral supplements fed to the dams. Fontenot (1953) found that calves from two-year-old heifers wintered on range and a forty per cent protein supplement were 4.3 pounds heavier at birth than were calves from heifers which received only a twenty per cent protein supplement.

Eckles (1919) stated that although breed and sex were the most important factors affecting the birth weights of calves, the ages and sizes of the dams were also important. Calves from cows from two to four years of age were found by Eckles to be lighter at birth than were calves from older cows. Withycombe et al. (1930) found that calves from two-year-old cows were nearly ten pounds lighter at birth than were calves from six-year-old cows. There was a gradual increase in birth weights of calves as their dams increased in age from two until six years. There was no increase beyond six years. Knapp et al. (1940) showed that a cow's first calf was lighter at birth than her subsequent calves, but they could find no differences in birth weights among the subsequent calves. The difference in birth weights between the first and second calves averaged six pounds. In addition these workers found a correlation of .22 between the weights of dams and the birth weights of their calves. The dam effect upon the birth weights of calves was highly significant . Knapp *et al*. (1942) found that calves from two-year-old cows were 10 pounds lighter at birth than were calves from four-year-old cows, but again they could find no differences due to ages beyond four years. When between cow differences were eliminated there was a correlation of .18 between the fall weights of the cows and the birth weights of their calves. Dawson *et al*. (1947) found that the birth weights of calves increased as the age of the dams increased until the dams were six years of age. The regression of birth weights of calves in pounds upon ages of dams in months was .23 for male calves and .20 for female calves. The correlation between the ages of the dams and the birth weights of their calves was .45 for male calves and .35 for female calves. A total of 402 calves were involved in that study. Burris and Blunn (1952) found a steady increase in birth weights of calves due to the age of their dams until the dams were nine or ten years old. The greatest difference, however, was between cows of two to three and those of three to four years of age. Koch and Clark (1955) found that the birth weights of calves increased with the ages of their dams until the dams were six years of age. The greatest difference was between cows three (first calf) and four (second calf) years old. The difference between these two age groups were four pounds. Gregory *et al*. (1950) found a correlation of .21 between the weights of cows after calving and the birth weights of their calves.

Several workers have shown that there are differences in birth weights of calves due to the calves' sires. Knapp et al. (1942) found that 10 per cent of the total variance of birth weights of calves was due to their sires. Other important sources of variance were dams (19 per cent), and sex of the calves (10 per cent). Gerlaugh et al. (1951) stated that the size of the sire seemed to influence the weights of his calves at birth. They also found significant differences in birth weights of calves due to the breed of their sires. Gregory et al. (1950) found that there was a significant difference in birth weights of calves due to sire effects. Gregory and his co-workers also determined the heritability of birth weights to be .45 when computed by a paternal half-sib correlation. Dawson et al. (1947) found the heritability of birth weights to be .29 before adjusting for known cow differences. However, when these differences were removed, the heritability figure was decreased to .11. This also was based upon a paternal half-sib correlation. Knapp and Clark (1950) found that birth weights of beef calves had a heritability of .53 with a lower fiducial limit of .26. The paternal half-sib correlation from which this estimate was derived involved 110 sire-progeny groups. Burris and Blunn (1952) found by paternal half-sib correlation that the heritability of birth weights was .22.

A great many workers have shown that there are differences among birth weights of calves due to sex and breed. Generally bull calves are about five pounds heavier than heifer calves, and Hereford calves are several pounds heavier than Angus calves or Hereford-Angus cross-breds. Gerlaugh et al. (1950) found that reciprocal crosses of Hereford X Angus gave identical birth weights of calves. These birth weights were intermediate to the weights of Herefords and those of Angus. The findings of several workers are summarized in Table I.

TABLE I

EFFECTS OF SEX AND BREED UPON BIRTH WEIGHTS (LBS.)

Source of Data	Number per sub-group	Breed						Sex Diff. (M - F)	Breed Diff. (H - A)
		Her.		Angus		H. X A.			
		M	F	M	F	M	F		
Gerlaugh 1951	50	69	68	62	56	66	63	3	9
Burris 1952	85	70	65	67	62			5	3
Knapp 1942	385	77	71					6	
Dawson 1947	200	72	69					3	
Woolfolk 1949	175	76	72					4	
Gregory 1950	140	74	69					5	
Koch 1955	2,975	78	73					5	

Although the evidence is partially conflicting, it appears that the birth weights of calves can be influenced by substantial differences in the rations fed their dams during gestation. The most marked differences occur when there are large differences in the amount of protein in the ration. The sizes and ages of the dams also affect the birth weights of their calves. The larger and older cows up until six years of age have heavier calves than do smaller or younger cows. There are pronounced differences in birth weights of calves due to their sires. Birth weights are also influenced by breed and by sex.

There has been very little work designed to determine whether those factors which affect birth weights also influence the extent of difficulty at calving. However, several authors (Albaugh and Strong, 1953; Guilbert and Hart, 1952; and Anonymous, 1951) have urged that only those yearling heifers weighing more than 600 pounds be bred. They stated that the weights of the heifers are more important than their ages at time of breeding. Each of these authors also stated that the use of small-boned, light-weight bulls would reduce calving difficulty. Gerlaugh (1951) found less calving trouble in Hereford cows calving as three-year-olds when they were mated to Angus sires than when Hereford sires were used. Gerlaugh suggested that the effect of size of sire within a breed might be more important than the breed effect in the incidence of difficult calving. Ensminger _et al_. (1955) studied the practices of American cattlemen and found that 22 per cent of all ranchers surveyed used cross-bred matings on first calf heifers. Presumably some of these cross-bred matings were made specifically for the purpose of reducing calving difficulty.

Although there is little experimental evidence to show that the size of the heifer at breeding and the type of sire to which she is mated affect calving difficulty, there is apparently popular opinion that difficulties of calving two-year-old heifers can be reduced by breeding only the larger heifers and only the smaller, more refined bulls.

CHAPTER III

DESCRIPTION OF THE DATA

Alibates and Channing

The purposes of this part of the study were to determine the relationship between birth weights of calves from two-year-old heifers and difficulty of the heifers at parturition, and to determine the effects which Angus and Hereford sires might have upon difficulty at parturition. It was also possible to determine the differences in degree of difficulty of calving between heifers dropping male calves and those dropping female calves.

The Alibates and Channing ranches are divisions of the Coldwater Cattle Company of Amarillo, Texas. Both ranches run grade Hereford cows under range conditions. In the summer of 1950 six-hundred yearling Hereford heifers were pasture mated at these ranches to 25 Angus and 40 Hereford bulls. The bulls of each breed were selected for the same characteristics and were generally similar in type. During the height of the calving season in the spring of 1951, two men were sent to Amarillo by the Oklahoma Agricultural Experiment Station for the purpose of gathering data on the birth weights, sex, and breed of the calves dropped. They also collected information on the difficulty the heifers had at parturition. The bred heifers had been wintered on the range, but were placed in an open pasture just prior to calving where they were checked several times during the day and night by the experiment station and ranch personnel. If it appeared that a cow would require manual assistance in calving, she was driven to a small pen where assistance could be given. The men in charge of the heifers were instructed to give no assistance to a heifer until it appeared certain that she could not calve unaided. When it was apparent that a heifer could not calve unaided, the calf was pulled either by hand or with mechanical pullers. After the calf was born it was weighed on a portable scale, and its birth weight, sex, breed, and state of viability were recorded. If the calf had been pulled or if its dam died these were also recorded. During the three weeks in which data were collected 100 Hereford and 61 cross-bred calves were dropped at the Channing ranch; 27 Hereford and 38 cross-bred calves were born during the data gathering period at Alibates. This made a total of 226 parturitions from which data were collected.

The same procedure was repeated at both ranches the next year (1951-52) except that only Hereford sires were used. An attempt was made to sort the sires into a large type and a small type group and to assign one group to each ranch. However, this was done by allowing the foreman at one ranch to choose, from the entire number of bulls available, those which he wanted, and the resulting grouping was quite unsuccessful. In general, the foreman selected only medium type bulls and left both the largest and smallest bulls in the same group. The same procedure was followed at calving time as in the previous year. When the data on calving difficulty were collected a distinction was made between calves pulled by hand and those pulled with mechanical pullers. Data were collected on 208 parturitions.

Stillwater Data

This part of the study was undertaken with several objectives in mind. First, the effects of the mature body size and general conformation of bulls upon the calving difficulty of heifers to which they were mated were to be investigated. Second, the differences between the effects of Angus and Hereford sires upon the difficulty at parturition of Hereford heifers were to be studied. Third, the effects that the ages and weights of heifers might have upon their calving performance were to be determined. Finally, the effects of all the foregoing factors upon birth weights and the relationship of birth weights to calving difficulty were to be investigated.

The yearling Hereford heifers used for this phase of the study were grade heifers from various projects of the Oklahoma Agricultural Experiment Station's experimental herd. The ages could be determined only for the heifers used in the first two years of the trial. The heifers were alloted and placed with the bulls on April 19 of each year. Only one bull was placed with each group of heifers in order that the sire might be determined for all calves. The heifers were grazed on the Lake Carl Blackwell range during both summer and winter. They were fed a protein supplement at various levels during the winter in connection with another experimental trial. (The levels varied from one pound of twenty per cent protein supplement to two pounds of forty per cent supplement per day. Not all levels were fed in any one year.) Since the various wintering rations were balanced over all the sire groups, and since no striking nutritional effects were apparent, no attention was paid to nutritional level when the data were analyzed. The heifers were weighed before being alloted to sires, and they were weighed at either monthly or bi-weekly intervals from then until they calved. The weight at calving used in the analysis was the weight of the heifer at the last regular weigh-day before she calved. Usually this weight was taken within two weeks of the date of calving. In a very few cases the weight was taken a month before the heifer calved. The weight at breeding was determined by subtracting 284 days from the calving date to determine a breeding date, and by then interpolating a weight between the weigh days on either side of this calculated breeding date.

The procedure at calving was generally similar to that discussed in connection with the Alibates and Channing trials. More extensive notes were taken on the degree of difficulty at parturition than at Alibates-Channing. The heifers were not watched nearly as closely at calving time as they were at Alibates-Channing. The sires used at Stillwater were classified as small type, medium type, or large type on the basis of body size and degree of refinement.

In 1951, forty-two calves were dropped. They were by two sires, a Hereford designated GH-1, and an Angus designated B-35. Both of these bulls were of the same general type, and both were classified as small.

In 1952, forty-six calves were dropped by five different sires. The sires used were:

(1) Hereford MI-10, a small-medium, very refined bull that was classified small.

(2) Hereford MI-6, a medium, blocky bull that was classified medium.

(3) Hereford L-4, a large, rugged bull that was classified large.

(4) Angus RA-1, a large-framed bull that was classified large.

(5) Angus B-35, used also in 1951 and listed above.

Seventy-two calves were dropped in 1953. They were sired by the following bulls:

(1) Hereford LD-5, a small-medium, refined bull that weighed 60 pounds at birth and was classified small.

(2) Hereford W-1, a medium, blocky bull that was classified medium.

(3) Hereford L-4, listed above.

(4) Angus QP-9, a medium, refined bull that weighed 52 pounds at birth and was classified medium.

(5) Angus QP-13, a large-framed bull that weighed 68 pounds at birth and was classified large.

(6) Angus RA-1, which was listed above.

In 1954, the final year of the test, 74 calves were born. They were sired by six different bulls which were as follows:

(1) Hereford 2-19, a medium-small, refined bull that weighed 65 pounds at birth and was classified small.

(2) Hereford 2-37, a medium sized bull that weighed 80 pounds at birth and was classified medium.

(3) Hereford 2-28, a large bull that weighed 95 pounds at birth and was classified large.

(4) Angus 102, a small, chunky bull that weighed 52 pounds at birth and was classified small.

(5) Angus 072, a medium, refined bull that weighed 68 pounds at birth and was classified medium.

(6) Angus 082, a large, rangey bull that weighed 63 pounds at birth and was classified large.

Throughout the four years of the experiment a total of 234 calves were dropped. They were sired by 16 different bulls. Four of these bulls were small Hereford bulls; three were medium Herefords; and two were large Hereford bulls. Two of the Angus bulls were small; two were medium; and three were large Angus bulls.

Construction of Calving Score

Since data which simply indicated whether a calf was born alive or dead and pulled or delivered without assistance could not be correlated or averaged, the notes which indicated the degree of difficulty at calving were converted to a somewhat crude and perhaps arbitrary numerical calving score.

This score was not equally precise for all phases of the study, because more complete notes of calving difficulty were kept for some phases than for others. The score devised from the 1951 data at Alibates-Channing had a scale of from one through five. One indicated that a calf had been born alive and without aid, and five indicated that both a calf and its dam had died. The intermediate positions of the scale are given in Table II. This score was expanded for the second year's (1952) calf crop at Alibates-Channing. This expansion was accomplished by making a separate classification for those calves which were pulled by hand and for those which were pulled with a mechanical puller. At Stillwater the calving notes "easy pulled" and "hard pulled" were used to make a further distinction within the category of calves pulled with mechanical pullers. There were also several caesarean sections and embryectomies at Stillwater. Since these were resorted to only when pulling had failed, it was assumed that both cow and calf would have died had they not been attempted. Therefore, calves removed by caesarean or embryectomy were given the same score as if both calf and cow had died. In rare instances changes of one unit up or down from the scale given in Table II were made if notations in the original records of calving difficulty made this seem advisable. For example, a one unit change upward was made in the score of a hand-pulled calf where an added notation read "very, very difficult to pull". Except in such cases, a score was made for each calf exactly as indicated in Table II.

TABLE II

DERIVATION OF CALVING SCORE

Method of Birth	Calf Live or Dead	Cow Live or Dead	Score
	Alibates and Channing-1951		
unaided	alive	alive	1
unaided	dead	alive	2
pulled	alive	alive	3
pulled	dead	alive	4
------	dead	dead	5
	Alibates and Channing-1952		
unaided	alive	alive	1
unaided	dead	alive	2
hand-pulled	alive	alive	3
hand-pulled	dead	alive	4
mech.-pulled	alive	alive	5
mech.-pulled	dead	alive	6
------------	dead	dead	7
	Stillwater-1951-54		
unaided	alive	alive	1
unaided	dead	alive	2
hand-pulled	alive	alive	3
hand-pulled	dead	alive	4
mech.-pulled easy	alive	alive	5
mech.-pulled easy	dead	alive	6
mech.-pulled hard	alive	alive	7
mech.-pulled hard	dead	alive	8
-------------	dead	dead	9
caesarean	----	----	9

CHAPTER IV

METHODS OF ANALYSIS

Relationships Among Ages, Sizes, Birth Weights, and Calving Scores

The degree of relationship between birth weights and calving scores was established, at Alibates-Channing and at Stillwater, by a simple correlation of the two factors. The formula used was that given by Snedecor (1946). Since the calving score used at Alibates-Channing in 1951 was computed differently from the score used in 1952, the two correlation coefficients were not combined into a single coefficient. For the same reason, Alibates-Channing data were not combined with Stillwater data. In cases where a "Z" transformation did not indicate significant differences among correlation coefficients measuring the same relationship but taken from different sets of data, the correlation coefficients were combined into a weighted average coefficient. The average coefficients were computed by using a "Z" transformation as outlined by Snedecor (1946).

The effects of the weights or ages of the dams upon their calving scores and upon the birth weights of their calves was also determined by simple correlation. However, these correlations were obtained from sums of squares computed on an intra-sire, intra-season basis. this was done by computing sums of squares for each sire-within-season group separately and pooling the separate computations. The variances in calving scores and in birth weights due to different sires and seasons, which would have affected the correlation coefficient, were thereby removed. The degrees of freedom associated with the number of sire-within-season groups were lost, which slightly increased the size of correlation coefficient needed for significance. Since correlation coefficients involving female calves were consistently smaller than those involving male calves, the correlation coefficients for separate sexes were not combined.

Mean Differences and Analysis of Variance

The data from the study included unequal numbers of male and female calves by each sire, and it included unequal total numbers of calves by the several sires. Those sire progeny groups in which there were nearly equal numbers of male and female calves and a large total number of calves were assumed to have given more reliable estimates of between sex differences than the sire groups with disparate sex ratios or few calves. Snedecor (1946) listed a method of weighting mean differences which places the most emphasis upon those comparisons which are most reliable from the standpoint of the numbers of items and their distribution.

This method was used by Chambers (1951) to compute mean differences among inbred and outbred lines of pigs, and it was used in this study to determine sex and breed differences in birth weights and calving scores. The formula and a set of data to illustrate the procedure are given in Table III. The data shown are a comparison of Angus and Hereford sires of different types. The trait considered was the calving scores of the heifers giving birth to calves by these sires. The number of degrees of freedom for "t" is the number associated with the mean square for error. This mean square is that between sires of the same type and breed classification.

After weighted mean differences between sexes were determined for calving scores and for birth weights, these mean differences were added to each female calf's calving score and birth weight, respectively. This procedure adjusted all birth weights and calving scores to a male calf equivalant value. This was an adjustment derived from a weighted average over all sires.

When all calving scores and birth weights had been sex-adjusted, the scores and birth weights were analyzed to estimate the various components of sire effect. A combination of nested and cross classification, complicated by unequal and disproportionate subclass numbers, was used in the analysis. Inequality existed in the number of calves by the several sires and in the number of sires within each sires-of-the-same-type-and-breed subgroup. This inequality was handled by the conventional method of analysis for unequal subclass numbers. That is, each subclass total was squared and then divided by the number of items within that particular subclass. The sum of the resulting values minus the correction factor was the sum of squares among the subclasses. The subgroups composed of calves by sires of the same type and breed, however, had disproportionate as well as unequal numbers of items within them. For example, there were proportionately more calves by large type Angus sires to calves by all Angus sires, than there were calves by large type Hereford sires to calves by all Hereford sires. Since it was expected that the effects of large type and of Angus breed would lie in opposite directions, this disproportionality might have introduced erroneously low estimates of type effects and of breed effects. Consequently, the disproportionality was corrected for by an approximate method listed by Snedecor (1946). Snedecor stated that this approximate method would, if interaction were negligible, give very reliable results. It is probably as reliable an estimate of the population values as would have been obtained from an exact method considering the limited number of degrees of freedom available. This method of correcting for disproportionality utilizes the same weighting of mean differences which is presented in the upper portion of Table III. It leads to weighted sums of squares for weighted mean differences which are obtained according to the method shown in Table III. The formulae used for the isolation of type and

TABLE III.

METHODS OF STATISTICAL ANALYSIS FOR OBTAINING WEIGHTED MEAN DIFFERENCES AND FOR COMPUTING SUMS OF SQUARES

Type of Bull	Hereford k_1	Hereford $\bar{x}_1$	Angus k_2	Angus $\bar{x}_2$	Weight (W)	H - A (D)	(W)(D)
Small	54	2.80	45	2.31	24.5	.49	12.0
Medium	38	4.08	28	2.43	16.1	1.65	26.6
Large	34	4.32	35	4.29	17.2	.03	.5
					57.9		39.1

$$\text{Weighted Mean Difference} = \frac{S(W)(D)}{S(W)} = \frac{39.1}{57.9} = .68 = \bar{D}$$

$$\text{Weight (W)} = \frac{(k_1)(k_2)}{k_1 + k_2} \qquad s_{\bar{D}} = \sqrt{\frac{\text{Mean Square, Error}}{S(W)}} = \sqrt{\frac{9.91}{57.9}}$$

$$t = \frac{\bar{D}}{s_{\bar{D}}} = \frac{.68}{.41} = 1.6$$

k_1 = Number of Hereford calves
$\bar{x}_1$ = Mean for Hereford calves
k_2 = Number of Angus calves
$\bar{x}_2$ = Mean for Angus calves
D = Difference between Hereford and Angus means
W = Weight assigned to each comparison
$s_{\bar{D}}$ = The Standard Error of the Weighted Mean Difference
S = Summation of

Source of Variance	d.f.	Formula for Sum of Squares (Sx^2)[2]	Example
Type	2	Sx^2 by Usual Means - Distortion Factor[1]	122 - (-4.59)
Breed	1	$(SWD)^2/\ S(W)$	1,534/ 57.9
T. x B.	2	$S(W)(D^2) - (SWD)^2/\ S(W)$	49.68 - 26.49

[1]Distortion Factor = Breed Sx^2 by Usual Method - $(SWD)^2/S(W)$
[2]Sx^2 = Sum of Squares

breed effects by means of this correction for disproportionality are listed, along with sample calculations, in the bottom portion of Table III.

It was felt that an estimate of the relative importance of each sire effect would be desirable. Therefore, estimates of the components of variance associated with the various effects were determined from the mean squares derived by the analysis of variance. The components of variance associated with each of these mean squares are shown in Table IV.

TABLE IV

COMPONENTS OF VARIANCE ASSOCIATED WITH MEAN SQUARES

Mean Square	Components of variance
Breed and Type of Sire	E + 14(S) + 39(BT)
Between Sires Within Breed and Type	E + 14(S)
Within Sires	E

E = Variance Within Sires
S = Variance Among Sires of the Same Type and Breed
BT = Variance Among Sires of different breeds and types.

CHAPTER V

RESULTS AND DISCUSSION

Relationship Between Birth Weights and Calving Scores

The relationship between the birth weights of calves and the calving scores of their dams was measured by a simple correlation of the two items. For the Alibates-Channing data, the correlation coefficients were determined separately for each ranch, breed of sire, and sex of calf. Although the separate coefficients were quite variable, a "Z" transformation did not indicate significant differences among correlation coefficients determined from calves of the same sex and season of birth. Consequently, weighted average correlation coefficients over all locations and breeds were determined from the separate correlation coefficients by use of "Z" transformation.

Although the differences in correlation coefficients between sexes of calves were not statistically significant, the difference between sexes was consistent throughout all traits measured. Therefore, it was felt best not to combine the data for heifers having calves of different sexes.

The correlation coefficients between birth weights and calving scores were computed on an inter-sire basis. They are listed in Table V.

TABLE V

CORRELATION COEFFICIENTS BETWEEN BIRTH WEIGHTS AND CALVING SCORES

Source of Data	Male Calves		Female Calves	
	d.f.	r	d.f.	r
Alibates, 1951				
Angus	21	.38	13	.42
Hereford	13	.58*	10	.69*
Channing, 1951				
Angus	35	.43**	22	.00
Hereford	56	.23	40	.13
Weighted Mean	121	.36**	81	.22*
Hereford, 1952				
Alibates	22	.19	27	.00
Channing	71	.42**	80	.22*
Weighted Mean	91	.38**	105	.16
Stillwater, 1951-1954	115	.42**	115	.33*

*Denotes significance at the 5% level of probability
**Denotes significance at the 1% level of probability

As was shown in Table V, the correlations between birth weights and calving scores were variable and quite low. However, most of the correlations with 70 or more degrees of freedom were statistically significant. On the average the calves which were heavier at birth caused more difficulty at parturition. However, none of the correlations were so large that one could attribute to birth weight variance a major part of the variance in calving scores.

In all comparisons involving a large number of calves, the correlations between birth weights and calving scores were higher for male calves than for female calves. The difference could be accounted for by a possible threshold effect of birth weights on calving scores. That is, there seems to be a level of birth weight below which little difficulty at calving is encountered. Consequently, variance in birth weights which are below this level is not associated with variance in calving scores. If a considerable number of the female calves but only a few of the male calves have birth weights below this possible threshold level, the correlation between birth weights and calving scores should be higher for male than for female calves.

Except for female calves at the Alibates Ranch in 1952, the refinements made in the calving score resulted in higher correlations of birth weights with calving scores. This indicated that the calving scores were actually measuring some real differences in degree of calving difficulty.

Although there was a real correlation between birth weights of calves and a rather arbitrary calving score which was designed to indicate the extent of difficulty experienced by their dams at parturition, this correlation was rather small. A great deal of the discrepance between calving scores and birth weights was perhaps due to the arbitrary nature of this scoring system. Appraisals of difficulty at calving were highly qualitative and subjective, since they were based upon such subjective decisions as whether a cow would calve without assistance or whether the calf should be pulled before the cow became weak. In addition there was no assurance that the gradations within the calving scores expressed differences in difficulty of calving in proportion to the importance of those differences.

There were undoubtedly other factors, separate from any characteristics of the calves, which affected calving scores. One of these was the sizes of the heifers; another may have been their ages. These factors, of course, reduced the correlation between calving scores and birth weights.

There was also the possibility that other factors connected with the calves, in addition to their birth weights, might have affected calving difficulty. One of these may have been the general conformation of the calves. That is, it is possible that calving scores may have been influenced by the size of some particular parts of the calves. Calves with disproportionately large heads or shoulders would be expected to give excessive trouble at calving time even though they might not be extremely heavy. An effect on calving difficulty attributable to the bodily shapes of the calves could be influenced by the calves' sires. The fact that the sire effect accounted for the same per cent of the variance in both birth weights and calving scores, despite the relatively low correlation between these two measurements, indicated that the sire might have affected calving difficulty of heifers to which he was mated in some way in addition to the direct effect he had upon the birth weights of their calves. However, it is probable that the majority of sire effect was the result of his influence on birth weights. This seems likely because there was no case, in this study, where a sire was responsible for small or large calving scores without being responsible for correspondingly light or heavy birth weights. Gerlaugh (1951) stated that calves sired by Angus bulls caused less trouble at calving than did calves sired by Hereford bulls, because of the smaller size of the Angus calves.

Average Birth Weights and Calving Scores

Table VI lists the average birth weights and calving scores which were found for the different years, breeds of sires, and sexes of calves at the Alibates and the Channing ranches. Standard deviations for birth weights and for calving scores were derived from the between calves of the same sex, season, location, and breed mean squares for birth weights and calving scores, respectively. The standard deviation of birth weights was 6.5 pounds, and the standard deviation of calving scores was 1.41 units. Since the calving scores of heifers which calved in 1951 were computed differently from those of the heifers which calved in 1952, the calving score means for the two years were not entirely comparable. Because of this the data for the two years were not combined. The variances of calving scores were not identical for the two years, but the difference between them was not important.

TABLE VI

AVERAGE BIRTH WEIGHTS AND CALVING SCORES
AT ALIBATES-CHANNING

Source of Data	Number of Calves M	Number of Calves F	Birth Weight M	Birth Weight F	Calving Score M	Calving Score F
1951						
Angus						
Alibates	23	15	60.4	58.9	2.48	2.25
Channing	37	24	62.2	54.6	2.76	1.71
Herefords						
Alibates	15	12	60.3	53.3	2.47	2.25
Channing	58	42	61.5	59.9	2.52	2.26
All Angus	60	39	61.5	56.0	2.65	1.92
All Hereford	73	54	61.0	58.0	2.51	2.26
All Calves	133	93	61.3	57.5	2.57	2.07
1952						
Hereford						
Alibates	24	29	67.0	60.3	3.21	2.31
Channing	73	82	63.0	59.8	3.58	2.66
All Calves	97	111	64.0	60.0	3.48	2.56

The average birth weights and calving scores obtained at Stillwater are grouped by the sires of the calves in Table VII. Standard deviations were computed for birth weights and for calving scores from the mean square for within sex and sire of calves. On this basis the standard deviation of birth weights was 7.3 pounds. The standard deviation of calving scores was 2.01 units. As can be seen from Table VII, birth weights and calving scores were quite similar for sires of the same type and of the same breed. The quite pronounced differences between sexes, types, and breeds will be discussed later.

TABLE VII

AVERAGE BIRTH WEIGHTS AND CALVING SCORES AT STILLWATER

Sire	Number of Calves		Birth Weight		Calving Scores	
	M	F	M	F	M	F
Small Herf.						
GH-1	9	11	64.3	62.7	1.67	2.27
MI-10	7	2	61.7	56.0	3.14	1.00
LD-5	4	8	62.3	55.3	2.00	1.50
2-19	7	6	63.1	64.1	3.00	3.17
Medium Herf.						
W-1	8	6	73.6	66.5	5.75	2.83
MI-6	6	4	69.0	58.3	3.50	2.00
2-37	8	6	66.4	59.5	4.25	2.17
Large Herf.						
L-4	9	15	68.9	63.0	3.44	3.13
2-28	7	3	66.9	66.3	5.14	5.00
Small Angus						
B-35	17	17	60.1	54.7	1.71	1.12
102	4	7	63.0	53.4	3.25	2.71
Medium Angus						
QP-9	7	6	65.6	61.3	3.00	1.00
072	6	9	59.0	59.1	1.17	2.11
Large Angus						
RA-1	11	8	69.9	62.8	3.82	1.88
QP-13	4	1	64.0	63.0	5.75	1.00
082	3	8	65.7	62.4	5.00	4.63
All Herf.	65	61	66.5	61.6	3.60	2.58
All Angus	52	56	63.6	58.4	2.89	2.13
All Calves	117	117	65.2	60.1	3.29	2.34

Sex Differences in Birth Weights and Calving Scores

Since there were unequal numbers of calves in the various breed and sire groups, some groups, which contained large numbers of calves, were more reliable indicators of the magnitude of sex differences than were others. In order that these groups might be given the major share of consideration, sex differences in birth weights and calving scores were determined by the method of weighted mean differences described in the METHODS OF ANALYSIS section. All mean differences were obtained by subtracting the birth weights or calving scores for female calves from those for male calves. These weighted mean differences are shown in Table VIII. They were derived from the unweighted means which were shown in Tables VI and VII.

The differences between the birth weights of male and female calves found in this study are in agreement with those other workers have reported. The seven authors listed in Table I reported differences between sexes in birth weights which averaged five pounds. This five pound average difference corresponds very well with the weighted mean difference between sexes of 4.8 pounds which was found at Stillwater and with the 3.8 and 4.2 pound differences found at Alibates-Channing.

As was shown in Table VIII, the effect of sex on calving score was nearly as pronounced as its effect on birth weight. The smaller between sex difference in

TABLE VIII

WEIGHTED MEAN DIFFERENCES BETWEEN BIRTH WEIGHTS OF MALE AND FEMALE CALVES AND BETWEEN CALVING SCORES OF COWS DROPPING MALE AND FEMALE CALVES

Source of Data	Number M	Number F	Birth Weight Wtd. Mean D. (M-F)	Birth Weight Std. Error of Diff.	Calving Score Wtd. Mean D. (M-F)	Calving Score Std. Error of Diff.
Alibates-Channing						
1951	133	93	3.84**	.899	.46**	.15
1952	97	111	4.16**	.875	.91**	.23
Still-Water						
1951-54	117	117	4.83**	.905	.98**	.27

*Denotes significance at the 5% level of probability
**Denotes significance at the 1% level of probability

calving scores at Alibates-Channing in 1951 as compared with later years was probably due to the less precise calving score used in 1951.

One of the interesting observations made from the data obtained at Stillwater was that there was a greater difference between the birth weights of bull and heifer calves sired by the medium type bulls than between bulls and heifers sired by either the small or large type bulls. There was also a larger difference between the calving scores for cows giving birth to bull and heifer calves sired by the medium type bulls than there was difference for those cows mated to sires of the other two groups. It is doubtful that differences in birth weights alone adequately account for these differences in calving scores between sex of calves.

It is possible that part of the discrepance in sex differences is due to a threshold effect. Both male and female calves by small type sires may be small enough at birth to be born with very little difficulty, and calves by large type sires may be so large that some calving difficulty is experienced by both sexes. The calves sired by medium type bulls would perhaps be intermediate in size and the heavier bull calves might create considerable difficulty, but their smaller sisters might be expected to be calved with considerably less difficulty if we assume such a threshold effect. It can be noted from Table IX that male calves sired by medium type bulls were comparable to the heifer calves sired by large type bulls in both birth weights and calving scores. Heifer calves sired by medium type bulls were comparable in birth weights and calving scores to the bull calves sired by small type bulls.

There was a very large difference in the difficulty of calving heifers giving birth to male and female calves. Approximately 63 per cent of the male calves involved in this study had to be pulled while only 41 per cent of the female calves were pulled. Twelve per cent of the female calves died at birth, while 19 per cent of the male calves died at this time.

Since there is no method for controlling the sex of these calves, the value of the knowledge of sex differences is that sex adjustments are made possible. Such sex-adjusted records are often used when selecting among individuals with few progeny.

TABLE IX

EFFECTS OF TYPE AND BREED OF SIRE UPON BIRTH WEIGHTS AND CALVING SCORES AT STILLWATER

Type and Breed of Sire	Number		Birth Weight		Calving Score	
	M	F	M	F	M	F
Small Type						
Hereford	27	27	63.0	60.3	2.44	2.15
Angus	21	24	60.7	54.3	2.00	1.58
All Small	48	51	62.0	57.5	2.25	1.88
Medium Type						
Hereford	22	16	69.7	61.8	4.59	2.38
Angus	13	15	62.5	60.0	2.15	1.67
All Medium	35	31	67.1	60.9	3.69	2.03
Large Type						
Hereford	16	18	68.0	63.6	4.19	3.44
Angus	18	17	67.9	62.6	4.44	3.12
All Large	34	35	67.9	63.1	4.32	3.29

Effects of Type and Breed of Sire Upon Birth Weights and Calving Scores

Hereford and Angus bulls were compared for effectiveness in reducing calving difficulty at Alibates-Channing in 1951 without regard for their general type. At Stillwater bulls of three different type classifications (small, medium, and large) within the Hereford and the Angus breeds were used. As was shown in Table VII, seven different Angus and nine different Hereford bulls were used at Stillwater. Since there were bulls classified as small, medium, and large within each breed, there were six type-and-breed subgroups. The average birth weights and calving scores within each of these six type-and-breed classifications were shown in Table IX. The standard deviations of birth weights and calving scores within these subgroups were 7.6 pounds for birth weight and 2.40 units for calving score.

Since there were unequal numbers of calves among the type-and-breed subgroups, breed effects were determined by the use of weighted mean differences. These differences are shown in Table X. Those differences computed from Alibates-Channing data were computed on an intra-sex basis, while those computed from Stillwater data were computed on a sex-adjusted basis. The sex-adjustment was made for these data in order that results obtained by this procedure might be compared to those obtained by analysis of variance.

TABLE X

WEIGHTED MEAN DIFFERENCES IN BIRTH WEIGHTS AND CALVING SCORES BETWEEN CALVES SIRED BY ANGUS AND HEREFORD BULLS

Source of Data	Number		Birth Weight		Calving Score	
	H	A	Wtd. Mean D. (H-A)	Std. Error of Diff.	Wtd. Mean D. (H-A)	Std. Error of Diff.
Alibates-Channing	127	99	.53	.91	.05	.15
Still-water	126	108	3.25*	1.25	.68	.41

*Denotes significance at the 5% level of probability

In order to determine the relative effects of breed and type of sire by a single comparison, the birth weights and calving scores from the Stillwater data were corrected to male equivalent values. This was done by adding five pounds to the birth weight of each of the female calves, and by adding one unit to the calving score of each cow which dropped a heifer calf. Average calving scores and birth weights for the six type-and-breed classifications were determined from the sex-adjusted data and are shown in Table XI.

TABLE XI

AVERAGE SEX ADJUSTED BIRTH WEIGHTS AND CALVING SCORES BY TYPE AND BREED OF SIRE SUBGROUPS

Mean Listed	Type and Breed of Sire					
	Small Angus	Medium Angus	Small Herf.	Medium Herf.	Large Angus	Large Herf.
Birth Weight[1]	59.9	63.9	64.2	68.5	67.7	68.3
Calving Score[2]	2.31	2.43	2.80	4.08	4.29	4.32

[1]Average standard error of birth weight means = 1.5
[2]Average standard error of calving score means = .51

The sex-adjusted data were also used for an analysis of variance designed to sort out the separate traits which together comprised the sires' effects upon birth weights and calving scores. The analysis was made according to the method outlined in the METHODS OF ANALYSIS section.

The mean square for sire effects and the mean square for between sires of the same type and breed were tested for significance by the mean square for within sires. The mean squares for type and for breed were tested for significance by the mean square for between sires within type and breed. The analysis of variance is shown in Table XII. An estimate of the percentage of total variance which may be attributed to sire effects is also given in Table XII. These percentages were derived from the corresponding mean squares as was shown in the METHODS OF ANALYSIS section.

TABLE XII

ANALYSIS OF VARIANCE OF STILLWATER CALVING DATA

Source of Variance	D.F.	Birth Weight		Calving Score	
		M.S.[1]	% of Var.	M.S.	% of Var.
Sires	15	214.4**	20	18.05**	21
Within Sires	218	51.2	80	3.94	79
Type and Breed of Sire	5	464.0*	16	34.34*	13
Type	2	785.0**		63.29*	
Breed	1	610.9*		26.49	
Interaction	2	90.2		11.60	
Sires Within Type and Breed	10	89.6	04	9.91**	08

*Denotes significance at the 5% level of probability
**Denotes significance at the 1% level of probability
[1]M.S. Denotes mean square

As was shown in Table X, there was little evidence of a breed effect on either calving scores or birth weights in the Alibates-Channing data. The cross-bred calves by Angus sires weighed only .53 of a pound less at birth than did the Hereford calves. This difference was smaller than its standard error. The differences in calving scores between calves by sires of the two breeds were essentially zero in these data. However, the Stillwater data did indicate a significant difference in birth weights between calves by Hereford and Angus sires. The 3.25 pound difference agrees very well with the four pound difference in birth weights between Hereford and Hereford X Angus cross-bred calves reported by Gerlaugh (1951). This birth weight difference between breeds was not entirely consistent among all type groups. The greatest share of the difference was between sire groups of the medium type classification. The Stillwater data did not show a significant difference in calving scores between cows mated to Hereford and Angus bulls. The analysis of variance of sex-adjusted birth weights and calving scores (Table XII) showed sire effects were highly significant for both birth weights and calving scores. The rest of the analysis gave less consistent results.

Although breed effects were significant for birth weights, they were not significant for calving scores. On the other hand, there was a highly significant difference in calving scores between sires of the same type and breed, and there was no corresponding significant difference in birth weights. Interactions between type of sire and breed of sire were obviously unimportant. Type of the sire had significant effects upon both birth weights and calving scores.

It must be remembered that the method of correcting for disproportionate subclass numbers which was used in the analysis was only approximate, and that the significance levels for type and for breed only are, therefore, not exact. Also the inequality of numbers of calves by each sire, while not affecting the reliability of the significance figures, may affect their applicability. That is, because some sires had more calves than others of the same type and breed group, they contributed more to all sums of squares than did the others. Therefore, some sires had a greater influence in the determination of mean squares than did others. However, since there was no way of determining whether a sire was typical of the group in which he was classified, and since no sire had enough calves to make sampling errors unimportant, it was desirable that the greatest number of calves be given the greatest weight. In any event, neither the approximation error nor the inequality of subclass numbers was likely to affect significance levels very much. Those values of "F" which were significant but extremely close to the five per cent level may not actually be statistically significant, while those near the one per cent level can be accepted as significant if not as highly significant. Any displacement of probability levels could, of course, occur in either direction.

The fact that type of sire exerted an influence upon the variance of birth weights and calving scores which was almost certainly statistically significant, indicates the importance of selecting small type bulls when breeding yearling Hereford heifers to calve at two years of age.

The percentage of the variance of birth weights (Table XII) which was associated with sires in this study was considerably higher than values reported previously. Knapp and others (1942) found 10 per cent of the variance of birth weights to be due to sires. However, Knapp's data included a component of variance due to sex which was removed by sex-adjustment in the present study. Also, this study was designed to make sire differences as large as possible.

The relative importance of type and breed can be estimated from examination of the sex-adjusted means for sires of the same type and breed which were shown in Table XI. The calving score means obviously fall into two groups. The one group consists of heifers bred to the small type Angus sires, the medium type Angus sires, and the small type Hereford sires. The range of the three means within this group was .49 of a calving score unit. The other group contains heifers bred to the medium type Hereford sires, the large type Angus sires, and the large type Hereford sires. The range of the means within this group was .24 of a calving score unit. However, the difference between the largest mean of the first group and the smallest mean of the second group was 1.28 calving score units. The sex-adjusted means for birth weights of calves fall into a similar pattern, except that the calves by small Angus bulls appear to be lighter at birth than the calves by other sire groups.

It appears, then, that small Angus, medium Angus, or small Hereford bulls are equally effective in reducing calving difficulty, and that medium Hereford, large Angus, and large Hereford bulls are equally prone to cause difficulty at calving in heifers to which they are mated.

The fact that the small type bulls of each breed were in the "low trouble" group and the large type bulls of each breed were in the "high trouble" group indicates the influence of type of sire. The presence of the medium Angus sires in the "low trouble" group and of the medium Hereford sires in the "high trouble" group indicates that, when type is not a decisive factor, there can be an important breed influence. Errors of classification may also have contributed to the dual position of medium type bulls.

Direct indications of the calving difficulties of two-year-old Hereford heifers are shown in Table XIII. The percentage of calves which were pulled and the percentage of cows and calves which died as a result of difficult parturition are, within each sire group, indicative of the sire's effect upon calving difficulty.

The difference between calving performance of heifers bred to large type bulls and those bred to small type bulls was extremely important. Twenty-nine per cent of the male calves and 31 per cent of the female calves sired by large type bulls died at birth, while only 17 per cent of the male calves and 8 per cent of the female calves sired by small type bulls died at that time. Four per cent of the heifers bred to small type sires died at parturition, and six per cent of the heifers bred to large type sires died at parturition.

TABLE XIII

PERCENTAGES OF CALVES PULLED AND PERCENTAGES OF CALVES AND COWS LOST

Sire Group	Number M	Number F	Percent Pulled M	Percent Pulled F	Percent Lost M	Percent Lost F	Percent of Cows Lost
1951 Alibates-Channing							
Angus	60	39	68	43	19	09	2.8
Hereford	73	54	67	58	13	06	3.8
1951-54 Stillwater							
Angus							
Small	21	24	33	21	10	00	2.2
Medium	13	15	23	20	31	13	3.6
Large	18	17	78	35	33	29	5.7
Hereford							
Small	27	27	41	30	22	15	5.6
Medium	22	16	86	38	18	19	5.3
Large	16	18	81	56	25	33	5.9
Summary							
Small	48	51	38	25	17	08	4.0
Medium	35	31	63	29	23	17	4.5
Large	34	35	79	46	29	31	5.8
Angus	112	95	55	33	20	11	3.4
Hereford	138	115	66	48	17	14	4.7
All	250	210	63	41	19	13	3.8

Effect of Age and Weight of Dam Upon Birth Weights and Calving Scores

A major objective of this study was to determine the effects which the ages and weights of the dams might have upon the dams' difficulty at parturition and upon the birth weights of their calves.

Birth dates were available for only 82 of the 234 heifers which calved at Stillwater. These 82 heifers calved during the first two years of the study. Some weights were available for all 234 heifers which calved at Stillwater. The weights and ages of the cows were not available at Alibates-Channing. The 82 heifers for which ages were available averaged 15.5 months (476 days) of age when bred. Their average age at calving was, of course, just a little over two years. The standard deviation of the ages was only 22 days. Weights at breeding were available for 234 heifers. These weights averaged 577 pounds, and their standard deviation was 56 pounds. The weights of the dams at the time they calved, which were available for 230 heifers, averaged 705 pounds with a standard deviation of 65 pounds.

The effects of the ages and weights of the dams upon their calving scores and upon the birth weights of their calves were determined by simple correlations of the traits. Although a "Z" transformation failed to indicate that there were significant differences between those correlations involving male calves and those involving female calves, there were consistently lower correlation coefficients for these factors when cows were dropping heifer calves than when they calved bull calves. Consequently, coefficients involving calves of different sexes were not pooled. The correlation coefficients which indicate the relationships of the weights and ages of the heifers at breeding with their calving scores and with the birth weights of their calves are shown in Table XIV. This Table also shows the relationships between the weights of the dams at calving and these same items.

TABLE XIV

CORRELATION OF AGES AND WEIGHTS OF DAMS WITH THEIR CALVING SCORES AND WITH THE BIRTH WEIGHTS OF THEIR CALVES

Trait Measured in the Dam	D.F.	Birth Weight of Calf	Calving Score of Dam
Weight of Dam at Breeding			
Male Calves	97	.26**	-.21*
Female Calves	97	.23*	-.14
Weight of Dam at Calving			
Male Calves	95	.42**	-.30**
Female Calves	95	.28**	-.09
Age of Dam at Breeding (days)			
Male Calves	31	.16	-.23
Female Calves	35	-.07	-.08

*Denotes significance at the 5% level of probability
**Denotes significance at the 1% level of probability

The correlations between the birth weights of calves and the weights of their dams at breeding or calving time which were derived from this study were consistent with those reported by Knapp et al. (1940), who found a correlation of .22 between the birth weights of calves and the weights of their dams. Gregory and others (1950) found a correlation of .21 between the weights of cows after calving and the birth weights of their calves. This was somewhat less than the .35 average correlation between the weights of heifers prior to calving and the birth weights of their calves which was found in this study. Since the present correlation was derived from weights of dams before calving rather than after calving, the birth weight of the calf made up a part of the weight of the dam. This undoubtedly increased the coefficient of correlation somewhat.

The correlations between the calving weights of the dams and the birth weights of their calves were higher than the correlations which involved the breeding weights of the dams. It was impossible to determine, from the present study, exactly what caused this difference among correlation coefficients. It may be that the heifers on the higher nutritional levels gained more weight during the winter and had heavier calves at birth than did the calves on the lower nutritional levels. This has been reported by Black et al. (1938), and Fontenot (1953). Each of these authors reported that the nutritional level of the dam influenced the birth weight of her calf. However, it is also possible that genetic differences among the dams are more closely associated with phenotype differences at calving time than at breeding time. There was also lack of independance between the weights of heifers just prior to calving and the birth weights of their calves which tended to increase the correlation between the two items.

The correlations between the ages of the dams and the birth weights of their calves were not significant. Many other workers have reported a positive correlation between the age of the dam and the birth weight of her calf. (Eckles, 1919; Withycombe et al., 1930; Knapp et al., 1940; Dawson et al., 1947; and Koch and Clark, 1955.) However, these studies were concerned with measuring the difference between the birth weights of the first calf and subsequent calves from the same cow. The age differences between records, therefore, were at least one year. In the present study, the standard deviation of age of dams was only 22 days. These differences among the ages of the dams were probably not large enough to affect the birth weights of their first calves to a noticeable degree.

In order to show the relationships between birth weights or calving scores and weights or ages of the dams more clearly than was done by correlation coefficients, the heifers were divided into three groups on the basis of weight at breeding and into three groups on the basis of age. The mean calving scores and birth weights for these groups were then compared. The heifers which dropped male calves were grouped and compared separately from those which dropped female calves. Of the heifers which gave birth to male calves, one-third weighed less than 555 pounds at breeding; one-third weighed between 555 and 603 pounds; and one-third weighed 604 pounds or more. The youngest third of the heifers dropping male calves was less than 470 days old at the time of breeding. The middle third was between 470 and 491 days old, and the oldest third was more than 491 days of age when bred.

One-third of the heifers dropping female calves weighed less than 541 pounds at breeding. One-third weighed between 541 pounds and 570 pounds, and one-third weighed over 570 pounds. The age brackets also broke at lower levels for the groups of heifers dropping heifer calves than for those dropping bull calves. One-third of the heifers which gave birth to heifer calves was less than 466 days of age at breeding; one-third was between 466 and 481 days of age, and the oldest third was more than 481 days old when bred. The average birth weights and calving scores associated with these age and weight groups are listed in Table XV.

This division of the dams into three weight groups indicated a 4.1 pound difference between the birth weights of calves from the heaviest group of heifers and those from the lightest group. However, the age classifications showed no differences between groups. In general, then, weight of the dam at this young age seems to be more closely associated with the birth weight of her calf than is her age.

TABLE XV

AVERAGE BIRTH WEIGHTS OF CALVES AND CALVING SCORES OF DAMS BY WEIGHTS AND AGES OF DAMS AT BREEDING

Weight or Age Classification of Dam	Number		Birth Weight		Calving Score	
	M	F	M	F	M	F
Weight Classification						
Lightest Third	39	39	63.4	57.9	3.68	2.64
Middle Third	39	39	64.6	60.3	3.34	2.72
Heaviest Third	39	39	67.5	62.1	2.85	1.72
Age Classification						
Youngest Third	13	14	61.2	57.0	2.08	1.60
Middle Third	13	14	64.4	62.7	2.46	3.08
Oldest Third	13	15	62.9	60.8	1.92	1.46

The correlations between the weights of the dams and their calving scores were considerably smaller than those correlations which involved birth weights. However, the correlations for heifers dropping male calves were significant for both breeding and calving weights. The correlations involving female calves were not significant. This may have been due to the same type of threshold effect as was discussed earlier. However, there was an indication that an increase in the size of the dam did reduce calving difficulty to some extent. This was more clearly shown when the heifers were grouped into three separate weight classifications. The average calving score for the lightest one-third of the heifers was .88 of a unit greater than the average calving score for the heaviest one-third of the heifers.

The principal reason for the small correlation between the sizes of the heifers and their calving scores was probably that as the heifers increased in size their calves increased in birth weight. Since increased birth weights caused increased difficulty at calving, the tendency of larger heifers to have less trouble at parturition was partly offset by the tendency of larger heifers to have large calves.

There was no significant correlation between the ages of the heifers and their calving scores, and the average difference in calving score between the oldest and youngest third of the heifers was only .15. This was probably due to the small variance in the ages of the heifers.

In general, the heavier heifers had less trouble at calving than the smaller heifers even though they gave birth to larger calves than did the smaller heifers. The greatest decrease in calving difficulty associated with increased size of the dams was found in the heaviest one-third of the heifers. The difference in the degree of calving difficulty was slight between the smallest and intermediate groups of heifers. Increased weight of the heifers at breeding had little effect on the reduction of calving difficulty unless the weight at breeding was in the neighborhood of 570 to 600 pounds. This observation is in line with the injunction of Albaugh and Strong (1953) that only heifers weighing 600 pounds of more at breeding time should be bred to calve at two years of age.

CHAPTER VI

SUMMARY AND CONCLUSIONS

If all other factors were equal, a heifer which calved when she was two years of age would be considerably more profitable than a heifer which did not calve until she was three. However, since heifers which calve at two are subject to a great deal of difficulty at parturition, all other factors cannot be considered equal, and the practice of calving heifers at two is not a wide spread practice among Western range men.

Because of the economic advantage which two-year-old calving would have if death losses could be avoided, a study was undertaken to determine whether calving difficulty could be reduced by breeding only the large heifers as yearlings and by breeding them to bulls of a particular type or breed. It was also possible to examine the relationship between the birth weights of calves and the calving difficulty of their dams, and to examine the influence which the sex of calves has upon the calving difficulty of their dams.

A study at Amarillo, Texas of 226 parturitions of two-year-old Hereford heifers showed no differences in calving difficulty due to the use of Angus and Hereford sires.

A study at Amarillo and at Stillwater of 668 parturitions did show a difference, both in birth weights of calves and in calving difficulties of their dams, due to the sex of the calves. Male calves were about five pounds heavier than heifer calves and suffered greater death losses at birth. A calving score was designed which indicated numerically the extent of difficulty at calving. Male calves were scored about one unit higher on this scale than female calves, which indicated more difficulty in the delivery of male calves than in the delivery of female calves.

Further studies at Stillwater of the effects of the type and breed of bulls upon calving difficulty in heifers to which they were mated were undertaken with more refined methods. Analysis of 234 birth weights and calving scores showed that there was a highly significant effect upon both birth weight and calving score due to sire of calf. Most of this sire effect was due to the type and breed of the sire; a lesser amount of the sire effect was due to sires of the same type and breed. The Hereford and Angus sires used included individuals classified as small, medium, or large in type. The small Angus, medium Angus, and small Hereford sires were effective in reducing the calving difficulty of the heifers to which they were bred. The use of medium Hereford, large Angus, and large Hereford bulls caused a great deal of calving difficulty in heifers to which they were mated. The differences between the two sire groups were 3.7 pounds in birth weight and 1.58 units in calving score. Death losses of calves by small type bulls were from one-third to one-half as great as death losses of calves by large type bulls.

The data were also examined to determine the effects of variations in sizes and ages of heifers upon birth weights and calving scores. There were no significant effects due to age, but there were significant effects due to size of heifers at breeding time. The heavier one-third of the heifers had less calving difficulty than did the lighter two-thirds. The difference was .81 of a unit of calving score. The heavier one-third of the heifers also had larger calves at birth than did the lighter two-thirds. The difference was 3.3 pounds.

In general, the data compiled for this study support the following conclusions:

(1) The amount of difficulty a heifer has at parturition is partly dependent both upon her own size and upon the size of her calf.

(2) Male calves are heavier at birth and cause more difficulty of calving than do female calves.

(3) The sire used has a highly significant effect upon both the birth weight of his calves and the degree of difficulty heifers have in calving.

(4) The use of small type sires of either the Hereford or Angus breeds can greatly reduce the degree of

difficulty and the extent of death loss at calving. The use of large type sires should be avoided.

(5) Calving difficulty and death loss can also be reduced by breeding only the larger heifers to calve at two years of age.

LITERATURE CITED

Albaugh, R., and H. T. Strong. 1953. Breeding yearling beef heifers. Cal. Agr. Exp. Sta. Circ. 433

Anonymous. 1951. Breeding heifers as yearlings. The Amer. Cattle Prod. XXXIII (Oct., 1951), p. 26.

Anonymous. 1954. Ninety per cent calf crop from yearling beef heifers. Farm Journal. LXXVIII. (April, 1954), p. 38.

Baker, A. L., and J. R. Quesenberry. 1944. Fertility of range beef cattle. J. Animal Sci. 3:78.

Black, W. H., J. R. Quesenberry, and A. L. Baker. 1938. Wintering beef cows on the range with and without a supplement of cottonseed cake. U.S.D.A. Tech. Bul. 603.

Bennett, J. A., L. A. Stoddart, and L. E. Harris. 1949. Should range heifers be bred as yearlings. Farm and Home Sci. X(June, 1949), p. 3. Utah Agr. Exp. Sta.

Burris, M. J., and C. T. Blunn. 1952. Some factors affecting gestation length and birth weight of beef cattle. J. Animal Sci. 11:34.

Chambers, D., and J. A. Whatley, Jr. 1951. Heterosis in crosses of inbred lines of Duroc swine. J. Animal Sci. 10:505.

Dawson, M. W., W. R. Phillips, and W. H. Black. 1947. Birth weights as a criterion of selection in beef cattle. J. Animal Sci. 6:247.

Eckles, C. H. 1916. The nutrients required to develop the bovine fetus. Mo. Agr. Exp. Sta. Res. Bul. 26.

Eckles, C. H. 1919. A study of the birth weight of calves. Mo. Agr. Exp. Sta. Res. Bul. 35.

Ensminger, M. E. 1951. Beef Cattle Husbandry. Danville, Ill:. Interstate Printers and Publishers.

Ensminger, M. E., M. W. Golgan, and W. L. Slocum. 1955. Problems and practices of American cattlemen. Wash. Agr. Exp. Sta. Bul. 562.

Fontenot, J. P. 1953. Supplements of different protein content for wintering beef cattle. M. S. thesis. Okla. A. and M. Coll. Library.

Gerlaugh, P., L. E. Kunkle, and D. C. Rife. 1950. Crossbreeding beef cattle. Ohio Agr. Exp. Sta. Res. Bul. 703.

Gregory, K. E., C. T. Blunn, and M. L. Baker. 1950. A study of some of the factors influencing birth and weaning weights of beef calves. J. Animal Sci. 9:338.

Guilbert, H. R., and G. H. Hart. 1952. California Beef Production. Cal. Agr. Exp. Sta. and Ext. Ser.

Knapp, B. Jr., A. L. Baker, J. R. Quesenberry, and R. T. Clark. 1942. Growth and production factors in range cattle. Mont. Agr. Exp. Sta. Bul. 400.

Knapp, B. Jr., and R. T. Clark. 1950. Revised estimates of heritability of economic characteristics in beef cattle. J. Animal Sci. 9:582.

Knapp, B. Jr., W. V. Lambert, and W. H. Black. 1940. Factors influencing length of gestation and birth weight in cattle. J. Agr. Res. 61:277.

Koch, R. M., and R. T. Clark. 1955. Influence of sex, season of birth, and age of dam on economic traits in range beef cattle. J. Animal Sci. 14:386.

Koch, R. M., E. W. Schleicher, and V. H. Arthaud. 1955. Weight changes in beef calves following birth. J. Animal Sci. 14:792.

Lasley, J. F. and R. Bogart. 1943. Some factors influencing reproductive efficiency of range cattle under artificial and natural breeding conditions. Mo. Agr. Exp. Sta. Res. Bul. 376.

Pope, L. S., J. D. Shroder, R. D. Humphrey, D. Stephens, and R. MacVicar. 1955. Effect of level of wintering and age at first calving on the performance of range beef cows. Okla. Agr. Exp. Sta. Mis. Pub. MP-43.

Snapp, R. R. 1952. Beef Cattle. Fourth edition. New York: John Wiley and Sons.

Snedecor, G. W. 1946. Statistical Methods. Fourth edition Ames: Iowa State Coll. Press.

Stanley, E. B. 1938. Nutritional studies with cattle on grassland type range in Arizona. Ariz. Agr. Exp. Sta. Tech. Bul. 79.

Warren, R. B. 1950. Factors affecting conception rate and gestation length in beef cattle. M. S. thesis. Okla. A. and M. Coll. Library.

Williams, W. L. 1943. Diseases of the Genital Organs of Domestic Animals. Third edition. Worchester: Ethel Williams Plimpton.

Withycombe, R., E. L. Potter, and F. M. Edwards. 1930. Deferred breeding of beef cows. Oregon Agr. Exp. Sta. Bul. 271.

Woodward, R. R., R. T. Clark, and J. N. Cummings. 1942. Studies on large and small type Hereford cattle. Mont. Agr. Exp. Sta. Bul. 401.

Woolfolk, E. J., and B. Knapp, Jr. 1949. Weight and gain of range calves as affected by rate of stocking. Mont. Agr. Exp. Sta. Bul. 463.

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