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To the Graduate Council:

I am submitting herewith a thesis written by Robert Marshall Stone, Jr. entitled "Factors Affecting Calving Interval in a Beef Cattle Herd in Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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FACTORS AFFECTING CALVING INTERVAL IN A BEEF CATTLE HERD IN TENNESSEE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Robert Marshall Stone, Jr.

December 1968

To

My parents, Marshall and Bess Stone,

without whose support and love this

study could not have been possible.

813189

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ABSTRACT

A seven-year study, involving 194 cows and 828 calving intervals, was conducted at the University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory, Oak Ridge, Tennessee.

This study was designed to evaluate the following effects on calving interval: source of dam, age of dam, radiation treatment of dam, weight change of dam during breeding season, previous parity of dam, sex of current calf, current calf's performance traits (unadjusted pre-weaning average daily gain and pre-weaning condition score) and sire of the calf for the following year.

Source, age of dam, and irradiation level of dam did not have a significant effect on calving interval.

Dam's weight change during the breeding season did exert influence on calving interval. Calving interval increased with the increase weight gain of the dam during the breeding season.

Previous parity of the dam had a pronounced effect on calving interval. Cows open the previous year had longer calving intervals and cows pregnant the previous year had shorter calving intervals.

Calf's pre-weaning average daily gain and condition score were an important source of variation in calving interval. Average daily gain of the calves had a negative response while condition score had a positive response on calving interval. Cows with calves with the highest average daily gain had the shortest calving interval; conversely, cows with calves with the highest condition score had the longest interval.

Sires used in breeding herd the first two years had a non-significant effect on calving interval while the sires used thereafter were highly significant. Confounding of age of dam apparently causes the difference between the sire groups.

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CHAPTER I

INTRODUCTION

With the ever increasing growth of the human population, the future of the beef cattle industry depends upon the ability of beef cattle to compete with other livestock and food products. This competition can be met only if the beef producer constantly strives to economize his operation.

Tremendous strides have been made during the past century in improving the type and quality of beef cattle. The old Longhorn has been replaced with an early maturing type of beef animals which produce a carcass with excellent eating qualities. However, another important factor that has to be considered is reproductive capacity. Geneticists agree that heritability of this trait is quite low and that such factors as disease, nutrition, adaptability and management are responsible for most of the differences, especially those found between herds.

Calving interval is defined as the time elapsing from the birth of a cow's calf until the birth date of her next calf. The calving interval comprises the interval from calving to first heat, number and length of estrous cycles prior to conception, and length of gestation. Any practices designed to shorten the length and increase the constancy of the calving interval would be desirable.

This study was designed to evaluate the following effects on calving interval: source of dam, age of dam, radiation treatment of

dam, weight change of dam during breeding season, previous parity of dam, sex of current calf, current calf's performance traits (unadjusted pre-weaning average daily gain and pre-weaning condition score) and sire of the calf for the following year.

CHAPTER II

REVIEW OF LITERATURE

Calving Interval

Heritability and repeatability estimates for calving interval are extremely low. Brown et al. (1954) reported that heritability of calving interval was practically zero and repeatability of calving interval was also zero. This work is in general agreement with Lindley et al. (1958). Lucker et al. (1963), in a study of 80 cows and 260 calves in an Angus and Hereford herd, found a repeatability estimate of 0.01 for calving interval.

Fagerlin et al. (1968), using 1,551 cows and their 8,491 calving records from a purebred Hereford herd in Colorado, found an average calving interval of 381 days based on individual records. Research in Oklahoma by Lindley et al. (1958) over a 17-year period with a Hereford herd bred for year-round calving showed a calving interval of 394.2 days.

A study of the records of 43 beef cows in California by Guilbert and McDonald (1933) indicated that 30 percent came into estrus between 40 and 60 days, and an additional 40 percent between 60 and 100 days post partum. They found no seasonal influence on this interval. Lasley and Bogart (1943) reported an average interval of 80.2 days to the post partum estrus in Hereford range cows while Warnick (1953) found an interval of 50.6 days in Angus and 58.2 days in Hereford cows on irrigated pastures in Oregon. Warnick (1955), in another study in Oregon,

reported that the average interval from parturition to the first estrus was 59.2 days in 54 Angus cows and 62.7 days in 97 Hereford cows during a 3-year period. In dairy cattle the average interval to the first post partum estrus varied from 32.1 (Olds and Seath, 1953) to 71.8 days for nursed cows (Clapp, 1937). Repeatability of this interval range was from 0.06 (Warnick, 1955) to 32.2 (Olds and Seath, 1953). Chapman and Casida (1937) found the heritability for post partum estrus to be practically zero.

McNutt (1924) observed 19 dairy animals and found the average estrous cycle to be 21 days. Hammond (1927) stated that the length of the normal estrous cycle in the cow averaged 19.5 days but varied from 17.5 to 24 days. Werner et al. (1938) observed the estrous cycles of 35 dairy heifers and found that 65.9 percent of 82 cycles ranged between 18 and 24 days. Alba and Asdell (1946) reported the model cycle length as 20 days for unbred heifers and 21 days for cows. They found that 85 percent of the cycles in heifers were between 18 and 22 days, whereas, in cows 84 percent were between 18 and 24 days. The mean for heifers was found to be 20.23 days with a standard deviation of 2.33 days. For cows the mean was 21.28 days with a standard deviation of 3.68 days. Lasley and Bogart (1943) found the mean cycle length for range beef cattle to be 19.6 ± 0.12 days, the modal length being 20 days, and 79 percent were between 17 and 23 days. Roark (1950) recorded the length of 504 estrous cycles of 110 cows and found that about 80 percent of the cycles were between 18 and 24 days. The mean cycle length was 21.4 days. Chapman and Casida (1934) found that intervals

between heats varied from 2 to 200 days. The mode was 21 days both for cows which were bred at the previous heat and for those which were not bred. The non-copulatory cycles averaged 32 days while the copulatory cycles averaged 37 days. When all cycles over 33 days were excluded, the mean for the non-copulatory group was 21 days and for the copulatory group, 22 days. Olds and Seath (1951) tabulated cycle lengths for 278 cows which included 3,776 intervals for an average of 13.6 per cow. The mean cycle length was 32.4 days with a range from 1 to 549 days. About 11.6 percent of the intervals were 53 days or over. Modal length was 22 days and this cycle length represented about 12 percent of the intervals. To obtain a mean of approximately 22 days, it was necessary to omit all intervals of 36 days or more. The standard deviation was 4.6 days. In this case, 82.2 percent of the intervals fell between 17 and 26 days. The composition of the mean square indicated a repeatability for single records of 0.069 for length of estrous cycle.

Studies by Burris and Blunn (1952) on influence of breed on gestation length indicated the average lengths for Angus, Hereford and Shorthorn to be 281.7, 286 and 284.3 days, respectively. Wheat and Riggs (1958) studied 608 gestation records and found the breed average for Angus to be 279.5 days; Hereford, 284.6 days; and Shorthorn, 281.3 days. They stated that heritability estimates based on the maternal half sib, full sib and paternal half sib correlations were .22, .36 and .50, respectively. Repeatability of gestation length was .21 and .19 for maternal sibs and full sibs, respectively. Lindley et al. (1958)

studied the reproductive performance of a purebred Hereford herd for the period from 1935 through 1952 and reported an average gestation length of 285.7 days. According to Williams (1927) the duration of pregnancy tends to vary with the health and vigor of the dam which depends upon heredity and numerous aspects of the environment.

Age of Dam

Herman and Edmondson (1950) found that age of the cow had a pronounced effect on the interval from calving to the first estrus. The interval was about 75 days for first-calf heifers (i.e., 1.5 to 2.5 years), about 50 to 60 days for cows from 2.5 to 7 years, and 60 to 90 days for cows past 7 years of age. Wiltbank et al. (1961) reported that interval from calving to first estrus in cows suckling calves was longer in the younger than in the older cows and shorter in the Angus breed than the Hereford breed. Lindley et al. (1958) indicated that young cows and old cows were significantly different from cows of intermediate ages in length of calving interval and that old cows had significantly longer intervals from calving to first breeding and from first breeding to conception. Warnick et al. (1967) studied a total of 1,025 potential pregnancies in Angus, Brahman, Brangus, Hereford and Santa Gertudis cattle, and found that age of the cow had a significant effect only in the Brahman, Hereford and Santa Gertudis breeds. Koone and Dillard (1967) recorded birth weights and gestation lengths for 1,327 single-birth Hereford calves over a 15 year period. They reported that age of dam had no measurable effect

on gestation length but did influence birth weight. These data are in general agreement with Reynolds et al. (1965), Lasley et al. (1961a), Lasley et al. (1961b) and Burris and Blunn (1952).

A study made on 4,753 cow-years over an 18 year period (Baker and Quesenberry, 1944) showed there was no significant effect of age of cow on fertility. It was reported that over 50 percent of the shy breeding cows could be identified by the time they reached four years of age. Johnson (1930) pointed out that the practice of breeding yearling heifers results in a high percentage of death losses and a low calf crop.

Weight Change of Dam

Johnson (1930) demonstrated that the major factor affecting the percent of the calf crop in North Dakota was the condition of the breeding herd during the breeding season. He pointed out that when cows were gaining in weight during the breeding season a high percentage of calves was almost invariably produced. This is in agreement with Wiltbank et al. (1962). Warnick et al. (1967) reported that weight change in Brahman and Santa Gertrudis cows had an influence on pregnancy rate, with cows losing the most weight having a lower pregnancy rate. Reynolds et al. (1965) reported that cow weight did influence birth weight of calf, but did not influence gestation length. Lucker et al. (1963) reported from a study of 80 cows and 260 calves in a Hereford and Angus herd that the repeatability estimates for cow weights for each year were 0.49.

CHAPTER III

EXPERIMENTAL PROCEDURE

Source of Data

Data used in this study were collected over a 7-year period (1961-1968) from a commercial Hereford herd owned by the University of Tennessee. The herd was located at the University of Tennessee-Atomic Energy Commission (UT-AEC) Agricultural Research Laboratory, Oak Ridge, Tennessee.

The herd was established in 1960 to evaluate the effects of irradiation on (1) fertility of the survivors, (2) viability and growth of the off-spring, (3) latent pathological response among the survivors, and (4) performance of the progeny by sire groups.

Thirty-four yearling heifers selected from the UT-AEC breeding herd, 42 yearling heifers from the University of Tennessee Experiment Station herd at Alcoa and 64 yearling heifers purchased in Texas made up the group irradiated in 1960.

Eighty heifer calves from the UT-AEC herd and 72 heifer calves purchased at a feeder calf sale in Brownsville, Tennessee, comprised the group irradiated in 1961.

The first group was exposed at 17-20 months of age to whole-body irradiation from a cobalt-60 facility. The second group was irradiated at a comparable age in 1961 with the same cobalt-60 source. Radiation was delivered as an acute single dose for the groups receiving

200, 300, and 400 roentgens (R) and the group receiving 600R had two exposures of 300R each, approximately 8 weeks apart. The dose-rate was approximately 0.75R per minute. Comparable number of non-irradiated heifers was taken from each source to act as controls.

Equal numbers of animals were assigned to each experimental group in 1960 and 1961. The survivors were allotted to sire groups and bred to calve first when they were 3 years old. Artificial insemination was used during the first half and natural service during the last half of the 90 day breeding season which began the first week in April. The first year the herd was allotted to four breeding groups and mated to bulls provided by the Animal Husbandry Department. After the first year, eight breeding groups of approximately 25 cows each were used. During the period of artificial insemination, detector bulls were turned with the cow herd twice each day to check the cows. All cows in estrus were artificially inseminated with semen from previous designated bulls. Following the artificial insemination period each bull was allowed to run with the group of cows to which he had previously been bred by artificial insemination.

Calves were treated with similar management practices. At birth each calf was weighed, tattooed and ear tagged. Calves were dehorned and male calves were castrated at 2 or 3 months of age. The calves were weighed and scored for type and condition at 120 days of age and again at weaning at about 8 months of age.

Description of Data

Observations on the dams included in this study were source, age,

irradiation level, spring and summer weights, previous parity, and a calving interval variable. Measurements on the calves were: month of birth, sex, birth weight, pre-weaning age, pre-weaning weight (approximately 120 days of age), subjective pre-weaning condition scores, and pre-weaning average daily gain. Cows with missing information concerning themselves or their calves were deleted from the study.

Spring weights used in this study were taken about the last of March or the first of April. Summer weights were taken about the last of June or the first of July.

Previous parity of the cow was thought to have an influence on calving interval. To study the influence of this variable the cows were divided into two major groups: cows "pregnant the previous year" and cows "open the previous year." In order not to penalize the first calf heifer by calling her open the previous year, a third group was added, "heifers the previous year."

The variable of most concern in this study was change in calving interval from year to year. Calving interval was derived by giving the cow which calved first within a year the number of zero and the cows which followed a number that corresponds to their own calving. The herd was ranked in this manner for each year. Variable between years was found for each individual animal by subtracting the rank given to earliest parturition from the last. By defining change in calving interval in this manner, the effects of year should have been incorporated into this random variable. Another advantage of defining change in calving interval in this manner is that previous parity could be

classified into three distinct levels. Cows open more than one consecutive year could be classified the same as a cow open one year.

Month of calving was divided into four months: January, February, March, April. Records which were used in this study showed there was one cow which calved in December and three that calved in May. Thus, the one December calf was classified as a January calf and the three born in May were classified as April calves. However, change in calving intervals was still determined relative to this late December calf in this particular year.

Calves were assigned condition scores by two or more members of the Animal Husbandry-Veterinary Science Department at the University of Tennessee. Coded scores of the graders for each calf were averaged to obtain the condition score. Numerical codes for condition score were high prime (17), prime (16), low prime (15), high choice (14) choice (13), low choice (12), high good (11), good (10), low good (9), high standard (8), standard (7), low standard (6).

Pre-weaning average daily gain was obtained by subtracting the birth weight from the weight at pre-weaning and dividing the difference by the pre-weaning age.

Method of Analysis

Primary interest of this study was to determine the effects of nine independent variables on one dependent variable, calving interval. The nine independent variables were: source of dam, age of dam, radiation treatment of dam, weight change of dam during breeding season,

CHAPTER IV

RESULTS AND DISCUSSION

In this study, 828 calving intervals of 194 cows that had complete records were analyzed to determine the effects of source of dam, age of dam, radiation treatment of dam, weight change of dam during breeding season, previous parity of the dam, sex of current calf, calf's pre-weaning average daily gain and condition score, and sire of the calf for the following year on calving interval.

Over the 7 year period, the mean calving interval increased 4.9 days per year.

Source and Age of Dam

Analyses of variance (Tables I and II) indicate the effect of source of dam and age of dam on calving interval was non-significant. This could be expected since the heifers were purchased at a comparable age and were treated alike from the time of purchase except for radiation treatment. Year of birth for the two age groups differed by only a year. After first calving of the second group, the environmental factors were the same for both groups. Guilbert and McDonald (1933) failed to detect a seasonal influence on the interval from parturition to first estrus. Williams (1927) reported that duration of pregnancy varied with the health of the dam which may be influenced by numerous aspects of the environment.

TABLE I

ANALYSIS OF VARIANCE FOR TRAITS STUDIED ON CALVING INTERVAL (ANALYSIS I)

Source	Degrees of Freedom	Mean Square
Source of dam	3	906.560
Age of dam	1	971.023
Radiation treatment of dam	4	61.022
Previous parity of dam	2	5,363.630**
Sex of current calf	1	652.950
Sire group I	7	484.477
Sire group II	37	2,374.123**
Regression of Y on:		
Weight change of dam	1	11,589.784**
Pre-weaning average daily gain of current calf	1	4,719.697**
Pre-weaning condition score of current calf	1	9,165.500**
Error	770	1,118.600

**P<.01. R^2 = .136.

TABLE II

ANALYSIS OF VARIANCE FOR TRAITS STUDIED ON CALVING INTERVAL (ANALYSIS II)

Source	Degree of Freedom	Mean Squares
Source of dam	3	1,252.848
Age of dam	1	1,511.472
Radiation treatment of dam	4	82.329
Previous parity of dam	2	3,933.619**
Sex of current calf	1	841.116
Sire group I	7	571.432
Sire group II	37	2,768.995**
Regression of Y on:		
Pre-weaning average daily gain of current calf	1	6,083.422**
Pre-weaning condition score of current calf	1	7,885.694**
Error	771	1,132.200

**P<.01. R^2 = .125.

Radiation Treatment of Dam

Effects of different levels of irradiation of the cows on calving interval were non-significant as shown in Tables I and II. The deviation from the overall mean calving interval in days for the various levels of radiation when dam's weight change was not considered was: control, -0.20; 200R, -0.13; 300R, -0.02; 400R, -0.76; and 600R, 1.61. When dam's weight change was considered the deviations for control, 200R, 300R, 400R, and 600R were -0.09, -0.23, 0.12, -0.70 and 0.91, respectively.

Dam's Weight Change

The analysis of variance (Table I) shows that dam's weight change during the breeding season had a highly significant ($P<.01$) effect on calving interval. These data imply that calving interval increased in a linear manner with the increase weight of the dam during the breeding season (Figure 1). Cows losing weight during breeding season tended to decrease their calving interval, whereas the cows gaining in weight tended to increase their interval.

Weight change during the breeding season is confounded with month of calving. The cows which calved early in the calving season tended to gain in weight; whereas, cows that calved late in the calving season or near the beginning of the breeding season tended to lose weight.

No data relative to the relationship between changes in cow weights during the breeding season and calving intervals were found

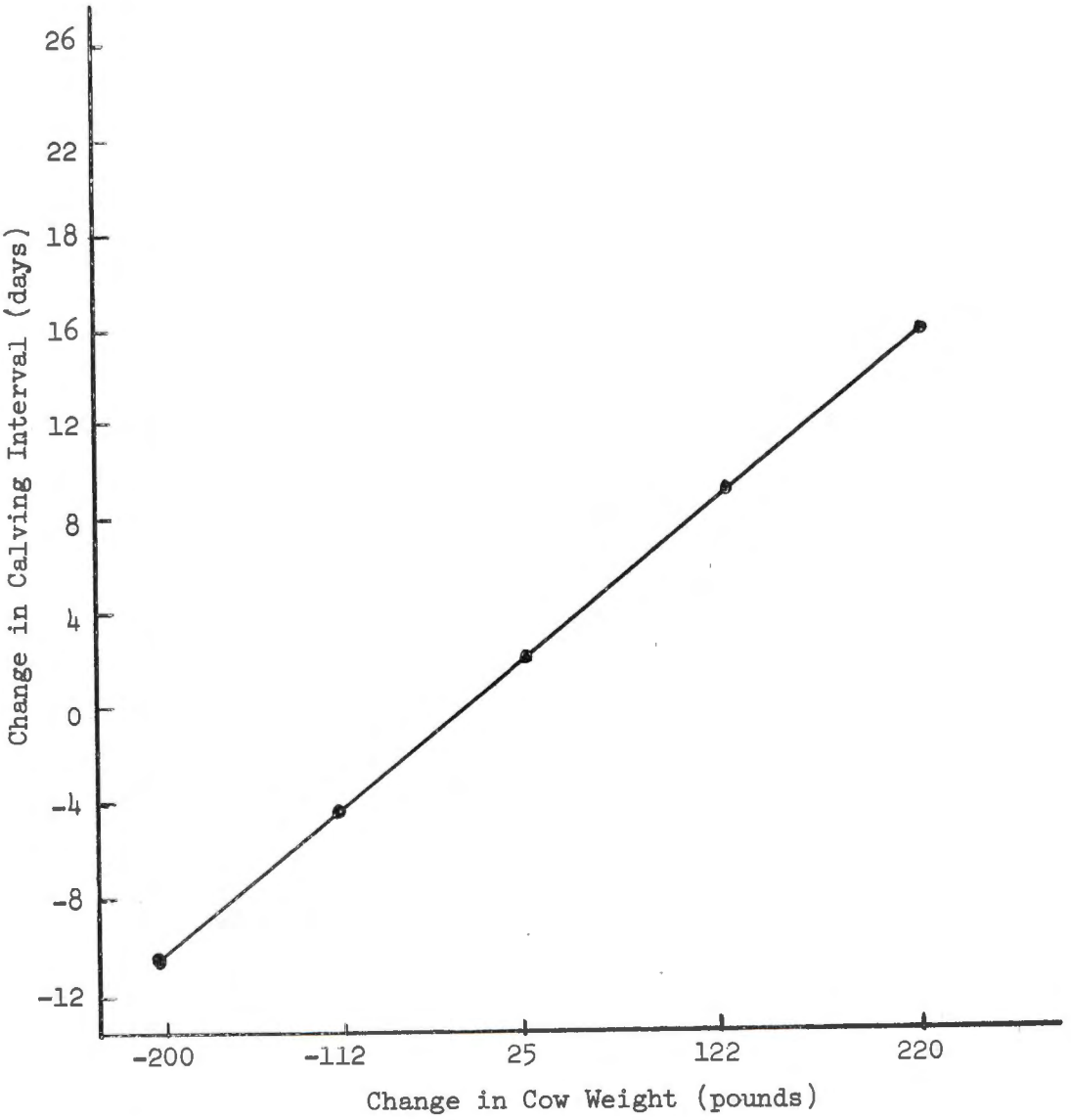


Figure 1. Regression of changes in cow weights during the breeding season on changes in calving intervals.

in the literature. However, Johnson (1930, Wiltbank et al. (1962) and Warnick et al. (1967) indicate that cows gaining during the breeding season had a higher conception rate than those not gaining in weight.

Previous Parity of Dam

Analysis of variance (Tables I and II, pages 18 and 19) shows that previous parity had a highly significant ($P<.01$) effect on calving interval. The pattern of response can be seen by least squares constants in Figure 2. Cows pregnant the previous year had a decreased interval. First calf heifers in analysis I, considering weight change, had positive response from the overall mean calving interval; whereas, in analysis II, not considering weight change, there was a negative change.

Figure 2 shows that cows pregnant the previous year tended to decrease in the calving interval approximately 2 days in analysis I and approximately 1 day in analysis II. Open cows tended to increase the interval 11 days in analysis I and 12 days in analysis II.

These data indicate that if a cow is open, her calving interval increased and did not return to the average of the herd or to the desirable length of 365 days. To obtain a desirable calving interval within the herd the data suggest that the open cows should be removed from the herd. This agrees with England et al. (1963), who reported that if a British breed cow failed to calve, she should be culled. However, another possible alternative would be to start the breeding season a month earlier for the cows that were open the previous year.

Sex of Current Calf

In this study, the effects of sex of current calf on subsequent calving interval were non-significant (Tables I and II, pages 18 and 19). This lack of effect of sex of current calf on calving interval agrees with Warnick (1955) who reported that sex of calf did not appear to influence the post partum estrual interval.

The deviations from the overall mean calving interval for sex of current calf considering dam's weight change for male and female were 0.94 and -0.94, respectively. When not considering weight change of dam, the deviations were for male, 1.07 and female, -1.07.

Calf's Pre-Weaning Average Daily Gain

In this study average daily gain had a highly significant ($P<.01$) effect on calving interval (Tables I and II).

These data indicate that calving interval and average daily gain have a negative linear relationship (Figure 3). Dams of the calves with the higher average daily gain tended to have shorter calving intervals. Least squares constants for average daily gain effects were negative in both analyses. Mean daily gain for the 7-year period was 1.64 pounds with a range of .75 to 2.48 pounds per calf.

Calf's Pre-Weaning Condition Score

Pre-weaning condition score of the calf had a highly significant effect ($P<.01$) on calving interval (Tables I and II). Condition score and calving interval had a positive linear relationship (Figure 4). Dams of the calves with the higher condition scores tended to have

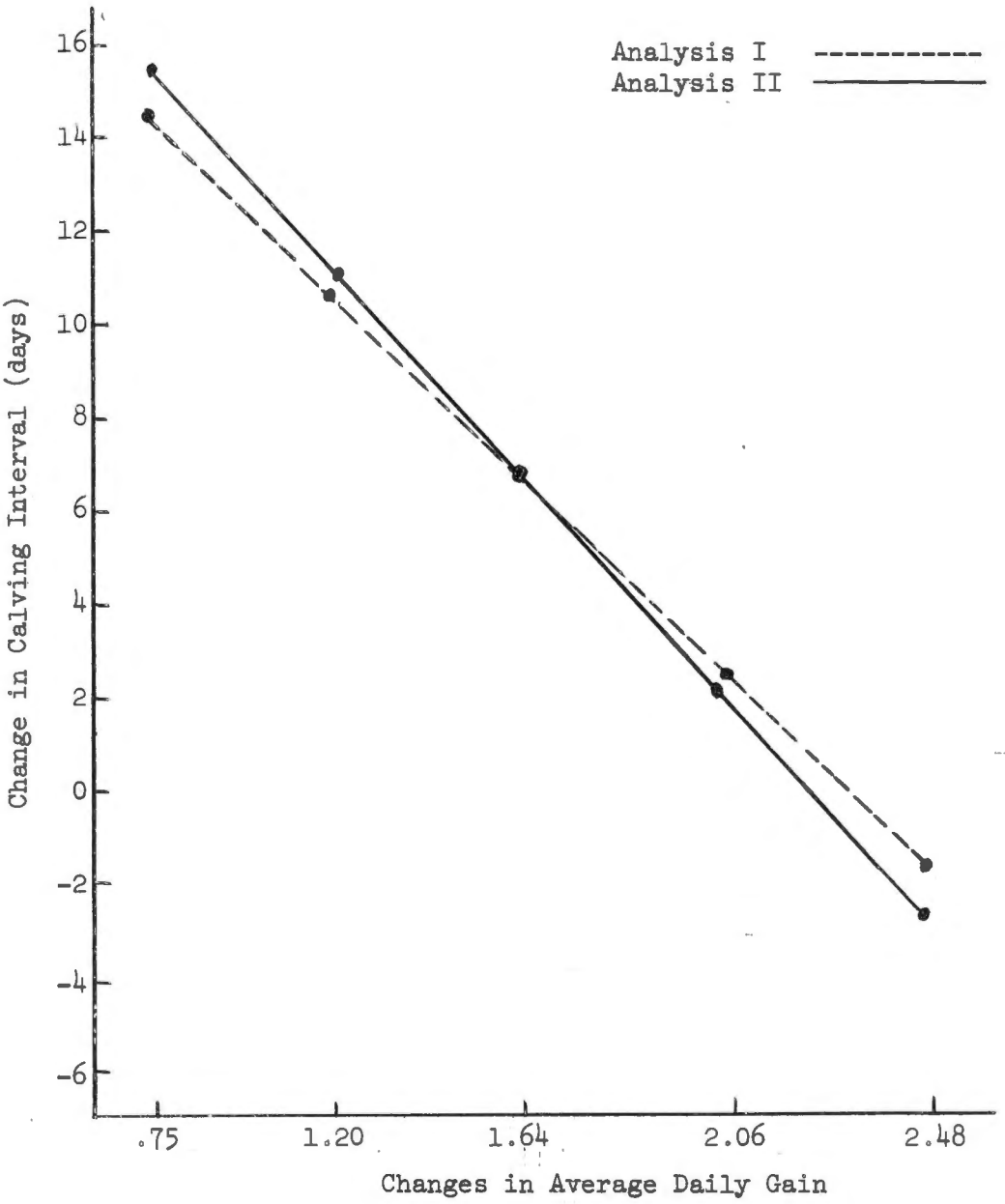


Figure 3. Regression of changes in calf's average daily gain on changes in calving intervals.

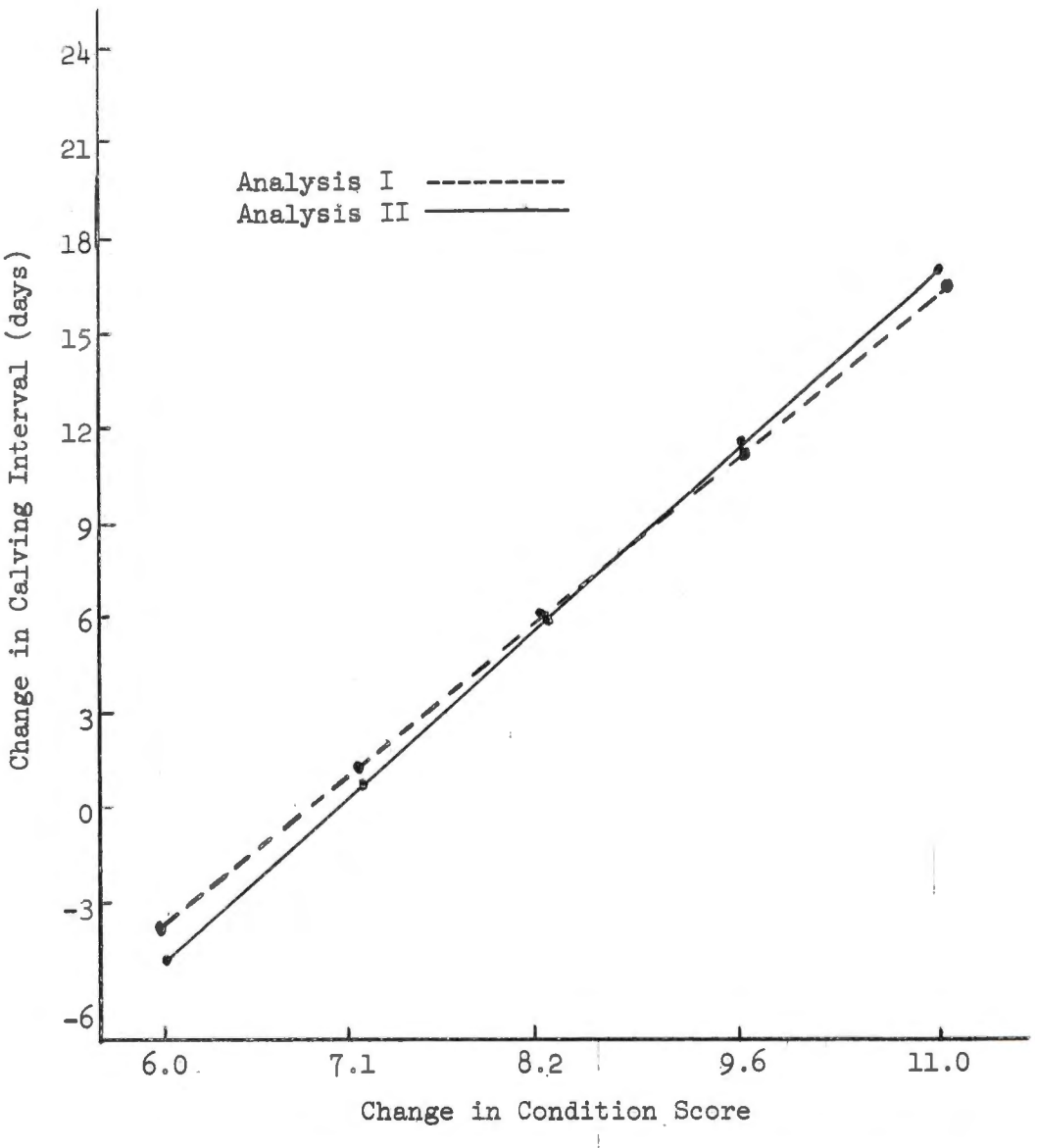


Figure 4. Regression of changes in calf's condition on changes in calving intervals.

longer calving intervals. Least squares constants for pre-weaning condition score were positive in both analyses. Mean condition score for the entire period was 8.2 with a range of 6.0 to 11.0. In contrast to the findings of this study, Warnick et al. (1967) found a negative relationship between the condition score of the calf and pregnancy status of the cow.

Weight change of dam during the breeding season and calf's pre-weaning average daily gain and condition score were significant sources of variation in calving interval, however, these effects tend to be influenced by month of birth of calf. The variances of change in calving interval were tended to non-homogenious on a within month of birth basis indicating the inappropriateness of an analysis of variance on a within month of birth basis even though statistically significant. Therefore, these results may not be biologically significant but may be expression of the effect of calf's month of birth. Previous parity was an important effect on calving interval.

Sire

The data were analyzed to determine the effects of sire of next year's calf on calving interval. Sires used in the years of 1961 and 1962 were not tied to sires used in the later years; therefore, the two groups were treated as separate groups. Analysis of variance (Tables I and II, pages 18 and 19) indicates that the effect of Group I sires on calving interval was non-significant; whereas, the effect of Group II sires was highly significant ($P<.01$).

Data for both analyses showed that 22 of the 38 sires in Group II tended to decrease the calving interval while the other 14 tended to increase the interval. The deviation from the overall mean calving interval in days ranged from a positive 44.9 to a negative 28.8 for analysis I and a positive 43.6 to a negative 29.9 for analysis II.

Confounding of the data does exist between sire and age of dam on calving interval. Group I sires were used when the cows were two and three years of age and Group II sires were used thereafter. Several workers have reported that calving interval varies with the age of dam. Herman and Edmondson (1950) found that the interval from calving to first estrus was longest for first-calf heifers and shortest for cows from 2.5 to 7 years, and increased for cows past 7 years of age; this is in agreement with Wiltbank (1961). Lindley et al. (1958) and Warnick et al. (1967) stated that young cows and old cows were significantly different in length of calving interval. Burris and Blunn (1952), Koone and Dillard (1967), Lasley et al. (1961a, 1961b), and Reynolds et al. (1965) reported that age of dam had no measurable effect on gestation length.

Group II had three sterile bulls that were not detected for several days before being replaced with fertile bulls. The breeding groups with replaced fertile bulls had longer calving intervals than the other groups.

Confounding of the cow's age with sire group and the presence of the sterile bulls in the second sire group could account for the difference that existed between the two sire groups.

Sires used in breeding herd the first two years had a non-significant effect on calving interval while the sires used thereafter were highly significant. Confounding of age of dam apparently causes the difference between the sire groups.

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