AN ANALYSIS OF THE RELATIVE DIFFERENCE IN THE WEIGHTS OF BOVINE MALES AND FEMALES AT BIRTH AND WEANING

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INTRODUCTION

There are a number of environmental factors that influence the birth and weaning weights of beef calves. These factors must be controlled before beef cattle records can be evaluated most efficiently. Control of these factors can sometimes be achieved by standardization of the physical environment or by use of correction factors which adjust the data for the effects of the various environmental factors. This study examines the effect of sex of the calf on birth and weaning weights. This environmental factor must be controlled statistically.

The purpose was to investigate the differences in birth and weaning weights of beef calves that are attributable to sex of the calf. The effects of a multiplicative correction procedure on the means and variances were also investigated. The data contained a wide range of birth and weaning weights. These were the result of nutritional treatments imposed on the dams, age of dam, sire of the calves and year of birth. Since there are wide variations in birth and weaning weights, the data lends itself to the type of study in which the main objective is to determine whether the sex effect is additive or nonadditive and to determine the best correction method.

LITERATURE REVIEW

Birth Weight

In some of the early work, Eckles (1919) used data collected during a 12 year period from the University of Missouri Dairy herd to study the important sources of variation in birth weights of calves. He found that breed was the most important source of variation whether the birth weight was expressed as pounds of calf or as percent of the dam's body weight. He also reported that the average birth weight of Holstein calves was 90 lb. which was approximately 8 percent of the dam's body weight; whereas the Jersey calves averaged 55 lb. at birth or approximately 6.5 percent of the dam's body weight. He also reported that the difference in birth weight due to sex varied among breeds. The males had an advantage of 8.0 lb. in calves from Ayrshire cows and 5.0 lb. in calves from Holstein and Jersey cows; however, there was only a 1.0 lb. difference exhibited in calves from Shorthorn cows.

Krasnov and Pak (1937) also reported that breed was a major source of variation in the difference in birth weight due to sex. They found a difference between males and females at birth of 1.86 kg. (4.1 lb.) in Tagil cattle and 3.0 kg. (6.6 lb.) in Red German cattle. These workers reported correlations between weight of dam and birth weight of calves of 0.56 and 0.42 for males and females, respectively.

An effect of breed on the difference between males and females at birth was noted by Knapp _et al._ (1940) in a study of 297 calving records from the Shorthorn and Milking Shorthorn herds at Beltsville, Maryland. In the Shorthorn cattle a highly significant ($P < .01$) advantage of 4.7 lb., which accounted for 6.5 percent of the variation in birth weight, was noted for the male calves. However, a non-significant advantage of 3.5 lb., accounting for only 2.1 percent of the variation in birth weight, was observed for the male calves of the Milking Shorthorn herd. A significant ($P < .05$) difference in gestation length due to sex of the calf was noted for the Shorthorn cows but not for the Milking Shorthorn cows. The difference in length of gestation accounted for 25 to 35 percent of the variation in birth weight attributable to sex.

The effect of sex on birth weight of calves was assessed using the records of 5067 Angus calves, 4778 Hereford calves and 231 Shorthorn calves collected by the Virginia Beef Cattle Improvement Association (Marlowe, 1962). The bull calves had an advantage over the heifer calves of 4.5, 4.0 and 3.5 lb. for the Angus, Hereford and Shorthorn calves, respectively.

The records of 502 calves from the foundation herd at the Nebraska Experiment Station at Lincoln were used to study some of the factors affecting birth weights of calves (Burris and Blunn, 1952). They found that birth weights differed only slightly among the three breeds studied. They reported sex differences at birth of 5.3 lb. for Angus calves, 4.5 lb. for Hereford calves, 4.9 lb. for Shorthorn calves and 4.8 lb. across all three breeds.

Seebeck and Campion (1964) studied the records of 400 Hereford and Aberdeen-Angus calves in Australia and found that bulls were 1.05 and 1.08 times as heavy as heifers at birth in the Hereford and Angus herds, respectively.

Fitch *et al.* (1924) studied 521 calf records from the Kansas State University dairy herd and reported that the difference in weight between males and females at birth ranged from 4 to 11 lb. The average difference between the sexes was 7.8 lb. Their data also indicated that the sire had a limited effect on birth weight.

Records collected from unrelated Holstein-Friesian herds in Wisconsin during the nine year period ending in 1945 were studied by Tyler *et al.* (1947). These workers reported a difference in birth weight of 5.2 lb. in favor of bull calves. Their data indicated that sex accounted for 7 percent of the total variation in birth weight.

A slight interaction was noted between the effects of age of dam and sex on birth weights (Dawson *et al.*, 1947). These workers studied records from the Shorthorn herd at Beltsville, Maryland, and found that the birth weight of males increased 0.23 lb. and birth weight of females increased 0.20 lb. for each month increase in the dam's age. This increase occurred up to six years of age with no further increase after that period. When these data were corrected for age of dam, bulls were 4.0 lb. heavier than heifers at birth. However, there was only a 3.5 lb. advantage in favor of the bull calves before the data were corrected.

The effect of crossbreeding on birth weight in a herd composed of Ayrshire, Friesian, Jersey and two and three breed crosses of these breeds was studied by Donald *et al.* (1962). Their results suggest an average difference of 6 lb. between males and females at birth, and that calves from first parity cows were 6.6 lb. lighter than calves from second and later parity cows.

The difference in birth weight attributable to sex of the calf in range cattle of the Hereford and Brahman breeds, the first cross of the two breeds and the back cross with a Hereford bull was studied by Lush et al. (1930). When records of 244 female and 258 male calves were pooled over years and breeds the bull calves were 5.4 lb. heavier than heifer calves at birth.

Data from crossbred cattle of Brahman-Angus and Africander-Angus ancestry collected in Louisiana were studied by Vernon et al. (1964). These workers reported significant ($P < .05$) differences between birth weight of males and females of 5.0 lb. in the Brahman-Angus lines and 3.8 lb. in the Africander-Angus lines.

The effect of sex on birth weight was studied using 770 calf records collected over a 14 year period from 112 Hereford cows at Miles City, Montana (Knapp et al., 1942). These data indicated that bull calves were 5.79 lb. heavier at birth than heifer calves. This difference due to sex was highly significant ($P < .01$) and accounted for 10 percent of the total variation in birth weight.

The difference in birth weight due to sex of the calves at the North Platte and Valentine Experiment Stations in Nebraska was studied by Gregory et al. (1950). The males were found to be 4.0 and 5.0 lb. heavier than the females at birth at the Valentine and North Platte stations, respectively.

Brinks et al. (1961) studied the effect of sex on birth weight of range Hereford calves using the records of 2151 heifer calves and 2281 bull calves from a test herd at Miles City, Montana, collected over a 22 year period and the records of 330 heifer and 345 bull calves from a purebred herd obtained over a 2 year period. Bulls were found to have an advantage in birth weight of 5.4 lb. and 5.2 lb. for the test herd and purebred herd, respectively.

Botkin and Whatley (1953) studied 620 calf records from the Lake Blackwell range at Stillwater, Oklahoma, and 98 calves from the Fort Reno Experiment Station at El Reno, Oklahoma, and found a difference of 4.4 lb. between the birth weights of males and females. In a similar study, Kieffer (1959) studied data from 360 bull and 305 heifer calves from four lines of Angus and Hereford cattle maintained at the Fort Reno Experiment Station. When these data were pooled over lines and years a difference in birth weight of 4.7 lb. existed in favor of the bull calves.

Koch and Clark (1955) studied the records of 5952 Hereford calves at Miles City, Montana, collected from 1926 to 1951. Bull calves were found to be 5.6 lb. heavier than heifer calves at birth.

The records of 259 bull calves and 273 heifer calves from purebred Hereford cows and 226 bull calves and 197 heifer calves from grade Hereford cows were studied by McCormick et al. (1956) to estimate the effect of sex upon birth weight. The difference in birth weight in favor of the bull calves was found to be 4.45 lb. in the purebred herd and 2.1 lb. in the grade herd.

A difference in birth weight between male and female calves of 2.3 lb. was demonstrated in 443 calf records from range Hereford cows at the Missouri station (Rice et al., 1954). This difference was highly significant ($P < .01$). In a similar study, conducted with purebred Hereford cattle in southern Ohio, Swiger (1961) found that bulls were 3.9 lb. heavier than heifers at birth.

Errors involved in obtaining birth weights were studied by Koch et al. (1955) using data from Hereford calves maintained on the Experiment Stations at Lincoln and Fort Robinson, Nebraska, and Fort Collins, Colorado.

A total of 218 calves were weighed at intervals of 12, 24, 36, 48 and 72 hours after birth. The calves gained 1.2, 1.5 and 1.8 lb. during the first three 24 hour periods after birth. These workers reported standard deviations of 1.9, 8.3 and 0.3 lb. for the errors in taking birth weight, difference among calves and weight changes over 12 hour periods, respectively. Comparisons of the average change in birth weight with the error involved and the large difference between calves indicates that adjusting for the weight changes in a 24 hour period or even a 48 hour period would not increase accuracy enough to be practical. The authors suggest that the errors associated with obtaining birth weights are largely a function of differences in the weighing time following parturition, the content of the digestive tract, mechanical failures of the scale and human errors in reading and recording the birth weights.

The results of various reports concerning the difference between male and female calves at birth have been summarized. These reports indicate that the difference in birth weight due to sex may vary from 1.0 to 8.0 lb. All of the results indicate that male calves are heavier at birth. Several workers have suggested that sex of the calf accounts for 2.0 to 8.0 percent of the total variation noted in birth weights.

Weaning Weight

It is generally accepted that males grow faster than females and therefore reach a greater weaning weight. This section of the literature review will be devoted to the magnitude of differences noted between males and females at weaning, and some of the factors contributing to this difference.

The records of 770 calves collected over a 14 year period at the Miles City, Montana, Experiment Station were analyzed to determine the effect of sex on weaning weight of calves (Knapp et al., 1942). A highly significant ($P < .01$) difference of 22 lb. was noted between males and females at weaning. This difference accounted for 7 percent of the total variation in weaning weights.

The difference due to sex in weaning weights of grade Hereford calves was studied with data collected over the 7 year period ending in 1943 at the New Mexico Agricultural College (Koger and Knox, 1945). Steers were found to have a highly significant ($P < .01$) advantage of 32 lb. at a standard age of 205 days.

Gregory et al. (1950) corrected the weaning weights of calves at the Valentine station to a standard age of 150 days and the weights of calves at the North Platte station to a standard age of 200 days. The male calves were found to have a weaning weight advantage of 3.0 lb. at the North Platte station and 14.0 lb. at the Valentine station. Since there was a large amount of variation in the weaning weights, neither of these differences was statistically significant. These results indicate that the difference between the sexes increases with the age of the calf.

Brown (1961) studied the effect of sex upon weaning weight in a herd of Hereford cattle with 253 calves and two herds of Angus cattle with 277 and 209 calves in the respective herds. He found that the male calves were 57, 33 and 22 lb. heavier than the heifer calves in the respective herds. The male calves in this study consisted of both bulls and steers since the bulls that would not be eligible for registration were castrated prior to weaning. This report also indicates that the difference between the sexes becomes larger with increasing age. It was noted that between 60 and 180 days of age the sex difference accounted for only 10 percent of the total variation in weight.

Seebeck and Campion (1964) studied 400 Hereford and Aberdeen-Angus calf records from Australia and reported that when the weaning weights were adjusted to a standard age of 255 days, the bull calves were 1.18 and 1.16 times as heavy as the heifer calves for the Aberdeen-Angus and Hereford cattle, respectively. A comparable ratio has been reported by Kieffer (1959) who found that bulls were 1.112 times as heavy as heifers at weaning.

Brown (1958) studied the records of 255 purebred Hereford calves and 212 purebred Angus calves collected at the Arkansas Experiment Station at Fayetteville during the years of 1940 to 1953. All records were corrected to a standard age of 240 days. In the Hereford calves the bulls were 107 lb. heavier than heifer calves, whereas the steer calves were only 25 lb. heavier than heifer calves. However, in the Angus herd the bulls were 67 lb. and the steers were only 23 lb. heavier than the heifers at weaning.

Peacock _et al._ (1960) studied records of 804 calves from crossbred cows of Brahman and Shorthorn ancestry maintained at the Range Cattle Experiment Station at Ona, Florida. A highly significant difference ($P < .01$) in 205 day adjusted weight of 31.9 lb. was observed between steers and heifers. However, when the data were adjusted for year of birth, pasture condition, age of dam and breeding, the difference in weaning weight attributable to sex was 28.1 lb. in favor of the male calves. These data suggest a highly significant ($P < .01$) breed by sex interaction. Thus indicating that the difference in weaning weight due to sex was not the same over all breeds. In a similar study, Reynolds et al. (1958) investigated records of 2528 calves at the Florida Range Station. These calves were of Brahman and Shorthorn breeding with crosses involving Brahman, Shorthorn, Angus, Hereford, Santa Gertrudis and native cattle. A difference due to sex of 34 lb. was observed in favor of the steer calves at a standard age of 205 days.

A study of range cattle of the Hereford and Brahman breeds and first and back crosses of the two breeds was conducted by Lush et al. (1930). These workers reported that when the data was pooled over years and breeds the steer calves were 25.5 lb. heavier than the heifer calves at weaning.

Data collected during the period from 1932 to 1957 from crossbred cattle of Brahman-Angus and Africander-Angus ancestry maintained at the Iberia Livestock Experiment Station at Jeanerette, Louisiana, were studied by Vernon et al. (1964) to determine some of the factors affecting weaning weight of calves. Prior to 1953 the bulls were graded and the cull bulls were castrated at 140 days of age; therefore, no valid comparisons could be drawn with regard to the effect of sex on weaning weight prior to 1953. In the Brahman-Angus lines the bulls were 43 lb. heavier than the heifers, and in the Africander-Angus lines the bulls had a 38 lb. advantage over the heifers at 180 days of age. The data was further divided into "low" and "high" production years on the basis of 180 day adjusted weights. Upon further analysis a level of production by sex interaction that approached significance was demonstrated in the Brahman-Angus line. During the "low" years a difference due to sex of 41 lb. was observed in favor of the bull calves; however, during the "high" years the difference attributable to sex was 53 lb. The difference in the Africander-Angus lines was in the same direction but was not as great.

Data collected over a 25 year period at the Florida Everglades Station were used to study factors affecting weaning weight of calves (Clum et al., 1956). These data indicated that male calves were 25.2 lb. heavier than female calves at a standard age of 180 days. The observation was also made that as the mean weight of the calves increased the difference due to sex increased. The ratio of average steer weight to the average heifer weight was found to be 1.08.

Koch (1951) studied 745 calves from 180 Hereford cows at Miles City, Montana, and reported that bulls were 44 lb. heavier than heifers at an average weaning age of 176 days. The difference of 31 lb. between bulls and steers could be biased due to selection practiced in deciding which bulls were to be castrated.

The effect of sex on weaning weight of purebred and commercial calves was studied by Brinks et al. (1961). Records on 4432 calves from a test herd and 675 calves from a purebred herd of Hereford cattle were used for this study. These workers reported that steers were 20.9 lb. heavier than heifers, and bulls were 24.1 lb. heavier than heifers at a standard age of 180 days. These data also suggested that weights of bulls were more variable than those of heifers.

The records of 718 calves from the Oklahoma stations at Stillwater and El Reno were studied by Botkin and Whatley (1953) who reported a difference of 24.6 lb. between steers and heifers at a standard age of 210 days. In a similar study, Kieffer (1959) analyzed the records of 360 bull and 306 heifer calves of the Angus and Hereford breeds from the Fort Reno station to determine the effect of sex upon weaning weight. He reported that the bulls were 46 lb., or 1.112 times, heavier than the heifers at a standard age of 210 days. Comparable results were obtained in a study of purebred Hereford cattle from Southern Ohio, in which a difference of 45.4 lb. was demonstrated between bulls and heifers at an adjusted age of 230 days (Swiger, 1961).

Rollins and Guilbert (1954) studied the records from the purebred herd of Hereford cattle at Davis, California, and found that male calves had a 68 lb. advantage at weaning when the weaning weight was corrected to a standard age of 240 days by the use of 28 day weights. In a comparable study, records of purebred Hereford calves from two ranches in Arizona were employed to investigate the effects of sex on weaning weights of range calves (Pahnish _et al._, 1961). The results of this study indicated that bulls were from 44 to 99 lb. heavier than heifers at a standard age of 270 days after the data was corrected for age of dam.

Some factors affecting weaning weight of Hereford calves were studied with the records of 1737 calves from purebred and commercial herds at the Illinois Station at Dixon Springs (Evans _et al._, 1955). The males from the purebred herd were left as bulls until weaning, and the males from the grade herd were castrated at an early age. The bulls were 6.1 percent or 22 lb. heavier than the heifers in the purebred herd, and the steers were 4.1 percent or 17 lb. heavier than the heifers at a standard age of 210 days.

Koch and Clark (1955) examined the records of 5952 Hereford calves collected from 1926 to 1951 at Miles City, Montana. They reported that steer calves had an advantage of 26.2 lb. at a standard age of 182 days.

Marlowe and Gaines (1958) studied the records of 1673 calves obtained from 44 Angus, 19 Hereford and 3 Shorthorn herds through the Virginia Beef Cattle Improvement Association. They reported that when calf weights were adjusted to a standard age of 210 days the bulls were

15 lb. heavier than steers and steers were 30 lb. heavier than heifers. This study indicates that the bull calves gain 5 percent faster than steer calves and the steers in turn gain 8 percent faster than heifers. In a study with analogous data, Marlowe et al. (1958) found that bull calves were 19 lb. heavier than steer calves and steer calves in turn were 34 lb. heavier than heifer calves at an adjusted age of 205 days.

Blackmore et al. (1960) studied the difference between males and females at weaning using 245 male calves and 613 female calves from a herd of Holstein cattle at Iowa State University. This report indicated that the males were 22 lb. heavier than the females at 6 months of age. A highly significant ($P < .01$) sex by year interaction was also demonstrated. These workers also included a study of the weight differences between the sexes at a standard age of 180 days with first and second calf heifers from the North Montana Branch Experiment Station at Harve, Montana. For this study they used the records of 172 male and 119 female calves from three year old heifers and 96 male and 121 female calves from two year old heifers. Data collected from three year old cows indicated that steer calves had a 22 lb. advantage over the heifers, and in the data from two year old cows the steers had a 12 lb. advantage over heifers.

Creek and Nestel (1964) studied the difference attributable to sex in calves born in Jamaica. These workers studied the 210 day weights of 2351 calves of which 1202 were steers and 1149 were heifers. The steer calves averaged 380 lb., and the heifer calves averaged 353 lb. at weaning. The 27 lb. advantage of the steer calves was highly significant ($P < .01$). The average difference between steers and heifers was found to increase with age of the dam up to eight years of age and then it declined with increasing age of dam. The mean weaning weight plotted against age of dam was found to be linear for heifer calves and quadratic for steer calves. Therefore, suggesting that age of dam exerted a greater effect on the steer calves than on the heifer calves. These workers state that in view of the small response of the heifer to age of dam it would seem that cows of all ages are capable of supplying a maternal environment which is adequate for the female to express her growth potential whereas only cows in their peak production years supply an adequate maternal environment for steers. In this study steers were found to be more variable than heifers. The herds were divided into herds with a low sex difference (less than 26 lb.) and herds with a high sex difference (greater than 26 lb.). This division appeared to have a random effect on the mean weight of the heifers in that the mean weight of the heifers was the same for both groups. However, the division produced an age of dam by sex interaction in the group with a high sex difference. The fitted curves for the male calves were significantly ($P < .05$) different for the two groups. These workers also found a correlation of 0.48 ($P < .001$) between the average weight of male calves and the difference due to sex indicating that the male weight is associated with the difference between males and females. They also reported a regression coefficient of 3.12 ($P < .05$) for the weight of males regressed on the difference attributable to sex. Thus, suggesting that as the difference increases the weight of the males also increases.

Further evidence that males are more responsive to their environment than females is provided by the effects of creep feeding upon the difference between males and females at weaning. Nelson et al. (1955) reported that a 135 day creep feeding period increased the gains of steer calves by 138 lb.; whereas, it increased the gains of heifer calves by only 88 lb.

In a later study, Marlowe (1962) used vast numbers of data collected by the Virginia Beef Cattle Improvement Association and data from the Experiment Station herds to study some of the factors associated with weight changes in beef calves. He reported that bull calves gained 14 percent faster than heifers and steers were intermediate in that they gained 7 percent faster than heifers but 7 percent slower than bulls. These ratios were not affected by creep feeding in Angus calves. However, in Hereford calves the ratios between bulls and heifers and bulls and steers were increased, but the ratio between steers and heifers was decreased. In other words, the creep fed bulls gained 20 percent faster than the heifers and 16 percent faster than the steers, and the ratio between steers and heifers was reduced to 4 percent. In a more recent study, Marlowe et al. (1965) used 17,294 Angus and 11,663 Hereford calf records collected by the Virginia Beef Cattle Improvement Association to investigate some nongenetic factors affecting weaning weight of beef calves. In this study the steer calves grew 6 percent faster than heifer calves regardless of whether they were creep fed or not. At an adjusted age of 210 days the steer calves were 27 lb. heavier than heifer calves. The non-creep fed bulls were 23 lb. heavier than non-creep fed steers and the creep fed bulls were 35 lb. heavier than the creep fed steers at weaning. The results of this study suggest that bull calves are more responsive to their environment than either steer or heifer calves. However, no difference in response was noted between steers and heifers. The authors suggest that different sets of corrections should be used for creep fed and non-creep fed calves. In another study, the effect of creep feeding upon the difference in weaning weight of males and females was studied with data collected in Butler County, Kansas (Hamann et al., 1963). These workers found that the steer calves were 40 lb. heavier than the heifer calves at a standard age of 238 days. All corrections were greater for creep fed calves than non-creep fed calves.

McCormick et al. (1956) studied calf records from a purebred herd of Polled Hereford cattle collected from 1936 to 1948 and records from a herd of grade Hereford cattle collected during the years of 1936 to 1953. The purebred calves were creep fed during the entire period, and the calves from the grade herd were creep fed from 1944 to 1948. The difference in weaning weight attributable to sex was studied using data from 491 creep fed calves from the purebred herd, and the bull calves were found to be 38 lb. heavier than heifer calves at a standard age of 210 days. The records of 423 calves from the grade herd were separated into creep fed and non-creep fed calves for the analysis of weaning weights. An advantage of 4.0 lb. was observed in favor of the steer calves in the creep fed group; however, in contrast to the creep fed calves, the heifers of the non-creep fed group weighed 12 lb. more than the steer calves at a standard age of 210 days.

Rollins and Wagnon (1956) completed a genetic analysis of weaning weights of two herds of grade Hereford cattle at the San Joaquin Station in California. One of the herds was maintained at an optimum level of nutrition and the other was maintained at a sub-optimum level of nutrition. The difference in weights of the steers and heifers at a standard age of 240 days for the herd that received adequate nutrition was 31 lb. in favor of the steer calves. In contrast, the steers were only 18 lb. heavier than the heifers in the herd that received sub-optimum nutrition. These results provide further evidence that steers are more responsive to their environment than heifers.

Rice *et al.* (1954) studied the records of 443 range Hereford calves at the Missouri Experiment Station to assess the effect of sex upon weaning weight of calves. They demonstrated a highly significant ($P < .01$) difference of 28.8 lb. between males and females at a standard age of 205 days. Similar results were obtained by Mahmud and Cobb (1963) who studied data from 1306 Hereford calves collected from two ranches in Hawaii during the years from 1954 to 1960 to determine the effect of sex upon weaning weight. They found that bull calves weighed 27.5 lb. or 6 percent more than heifer calves at six months of age.

Neville (1962) studied 135 calves from grade and purebred Hereford cows in Georgia and noted that the steer calves were significantly ($P < .05$) heavier than the heifers at a standard age of 240 days. The magnitude of this difference was 14.6 lb.

Data from 28,493 calves collected in the Georgia Beef Cattle Improvement Association program during the eight year period from 1957 to 1964 were analyzed to determine the effects of sex and other factors upon the weaning weight of the beef calves (Thrift, 1964). The data were composed predominantly of records of purebred and grade Hereford, Angus and Santa Gertrudis cattle. At a standard age of 205 days the bull calves were 26.7 lb. heavier than the steer calves, and in turn, the steer calves were 17.0 lb. heavier than the heifer calves.

Data collected by the Oklahoma Beef Cattle Improvement Association during the years of 1959 through 1962 were analyzed to estimate the factors affecting weaning weight of Oklahoma beef calves (Cundiff, 1966). The records of 13,937 Hereford and Angus calves were used. The bull calves were found to have an advantage of 55 lb. over heifers and 44 lb. over steers at a standard age of 205 days. The author states that these comparisons are confounded with selection since the producers selected the larger more rapidly gaining males to be maintained as bulls.

In contrast to most other reports Sawyer et al. (1948) at Oregon reported that heifer calves were heavier than steer calves at a standard age of 30 weeks. However, this difference lacked statistical significance. McCormick et al. (1956) also reported that heifers were heavier than steers in their study. They found that non-creep fed heifers were 12 lb. heavier than non-creep fed steers at an adjusted age of 210 days.

The reports reviewed indicate that the difference in weaning weight due to sex may be quite variable. Factors that have been found to affect the difference between males and females are area, type of management, weaning age, breed, age of dam and nutrition of the dam. The differences attributable to sex at weaning have been found to range from 16 to 27 lb. between bulls and steers, 22 to 107 lb. between bulls and heifers and 13 to 31 lb. between steers and heifers. Two studies reported that heifers were heavier than steers at weaning. Several reports have indicated that sex accounts for 7 to 14 percent of the total variation in weaning weights.

Method of Correction

A number of workers have suggested that a multiplicative factor may be more appropriate than an additive factor to correct for the difference between males and females in birth and weaning weights. The multiplicative factor that is most often used is derived by the ratio of the average male weight to the average female weight.

Brinks et al. (1961) suggest that a multiplicative factor obtained from the ratio of the mean weight of the sexes is more satisfactory than an additive factor for correcting both birth and weaning weight in their data. However, they state that even though the multiplicative factor was superior, it still did not completely equalize the variances of the two sexes.

Pahnish et al. (1961) studied records of calves from two ranches and stated that the mean difference between the sexes was not an adequate correction factor since the data contained significant sex by year and sex by ranch interactions. These workers suggested that the average difference in weaning weight between males and females corrected for weaning age and age of dam on a within ranch and year basis would be a more realistic correction than the mean difference between sexes.

Blackmore et al. (1960) found that if an additive method of correction had been used to adjust weaning weights of heifer calves from two and three year old heifers to a steer equivalent, the sex difference would have increased in five of eleven years for calves from three year old heifers and three of seven years for calves from two year old heifers. Therefore, they concluded that an additive factor would not have been appropriate for their data.

Vernon et al. (1964) studied records from crossbred herds in Louisiana to determine some of the effects of sex upon weaning weight. They divided their data into low and high production years on the basis of weaning weight to study the effect of level of production on the difference in weaning weight attributable to sex. They used a simple ratio of the weight of the bulls to the weight of the heifers which was 1.14 as a correction factor. They noted that during the low years this factor over corrected the heifers; however, during the high years it under corrected the heifers.

Koch *et al.* (1959) studied the influence of sex upon birth weight and pre-weaning gain of 1434 bull and 1512 heifer calves from several of the Mid-western experiment stations. The authors suggest that the change in weights of bulls as compared to heifers may be expressed by the equation:

$$\frac{\hat{B}-\bar{B}}{H-\bar{H}} = \frac{S_b}{S_h}$$

where:

$\hat{B}$ = the adjusted weight or gain of bulls,

$\bar{B}$ = average weight or gain of bulls,

H = the actual weight or gain of heifers,

$\bar{H}$ = average weight or gain of heifers,

$\frac{S_b}{S_h}$ = ratio of the standard deviations of weight or gain within each sex.

Therefore, it can be seen that if the standard deviations are equal an additive adjustment would be appropriate. However, if the coefficients of variation are equal, the ratio of the mean values for the two sexes or a multiplicative factor would be appropriate. Averaged over all of the experiment stations the bulls were 5.2 lb. or 1.076 times heavier than heifers at birth. The results were not conclusive as to which type correction factor was most appropriate for adjusting birth weights. The average daily gain of the bull calves was 0.113 lb. or 1.073 times greater than the average daily gain of the heifer calves. A ratio of the mean average daily gains was recommended as a correction factor for the effect of sex on average daily gain. This study indicated that bulls were more variable than heifers, but the results lacked significance.

Koch *et al.* (1959) and Brown (1961) suggested that correction factors would generally be less accurate when applied in herds or environments other than those in which they were developed.

MATERIALS AND METHODS

The data involved in this study were collected during the ten year period from 1954 until 1963 from cows that were used in studies pertaining to level of winter feeding at the Fort Reno Experiment Station at El Reno, Oklahoma. The majority of the cows were maintained on various combinations of the following four basic levels of winter feeding; low level - loss of 20 percent of body weight, moderate level - loss of 10 percent of body weight, high level - loss of less than 5 percent of body weight, and very high level - full-fed 50 percent or 65 percent concentrate mixture during the entire wintering period. These winter weight changes were measured from early November until mid-April and included the loss due to parturition. The desired weight changes of all treatment groups except the very high level were achieved by supplementation with cottonseed cake and ground milo. The various combinations of these treatments have been described by Turman *et al.* (1964) and Smithson *et al.* (1964). Another set of treatments were based on daily feed intake as described by Zimmerman *et al.* (1959).

All calves were weighed and tattoed within 24 hours after birth. All calves were dehorned and vaccinated with the males being castrated at approximately six to eight weeks of age. Birth weights were measured to the nearest 1 lb. and weaning weights were obtained to the nearest

5 lb. The calves involved in this study were not creep fed and remained with their dams until an average age of approximately 210 days.

Records of 717 male and 838 female calves were available for this study. The age of the dams ranged from 2 to 15 years with the majority of the calves being calved by cows ranging in age from 2 to 7 years. A total of 77 sires obtained from the stations breeding herd were used during this period. The cows were allotted to breeding groups of 20 to 25 head each year on the basis of their past productivity, age, treatment and calving date.

The calf records were divided into sub-groups according to year of birth, age of dam, treatment of dam and sire of the calf. All sub-groups that did not contain at least one calf of each sex were removed from the data. There were a total of 297 sub-groups remaining, that contained 478 male and 501 female calves, after the incomplete sub-groups had been removed. One male and one female calf of each sub-group was randomly selected such that each sub-group contained one calf of each sex. The weaning weight records of these calves were corrected to a standard age of 210 days on the basis of individual average daily gain by the following formula:

$$\left[\frac{(\text{actual weaning weight} - \text{birth weight})}{\text{actual weaning age}} \times 210\right] + \text{birth weight.}$$

After the weaning weight had been corrected for age of the calf, the birth and weaning weights were handled in a similar manner for the statistical analysis.

The regression of the difference between the weights of the male and female of each pair on the average weight of the pair was calculated by the following formula:

$$\beta_{da} = \frac{\sum_{i=1}^{297} d_i a_i}{\sum_{i=1}^{297} a_i^2}$$

where:

β_{da} = regression coefficient for the sex difference on the average weight of the pair,

$\sum_{i=1}^{297} d_i a_i$ = corrected cross products of the difference and the average weight,

$\sum_{i=1}^{297} a_i^2$ = corrected sum of squares of the average weight of the pair.

A second set of regressions were calculated to study the effect of the average weight on the sex difference. These regressions are the weights of the male and female on the average of the pair and were calculated by the following formula:

$$\beta_{xa} = \frac{\sum_{i=1}^{297} x_i a_i}{\sum_{i=1}^{297} a_i^2}$$

where:

x = males or females,

β_{xa} = regression coefficient of the male or female of each pair on the average weight of the pair,

$\sum_{i=1}^{297} x_i a_i$ = corrected cross products of either males or females on the average weight,

$\sum_{i=1}^{297} a_i^2$ = corrected sum of squares of the average weight.

The weights of the females were then corrected to a male equivalent by multiplying the weight of the female by the ratio of the average weight of the males to the average weight of the females. The regression lines for the weight of males and females on the average weight of the pair were calculated for the corrected data.

An additional regression was calculated for the sex difference at weaning. This regression was the sex difference at weaning regressed on the difference due to sex at birth, and was calculated by the following formula:

$$\beta_{D_w D_b} = \frac{\sum_{i=1}^{297} D_{w_i} D_{b_i}}{\sum_{i=1}^{297} D_{b_i}^2}$$

where:

$\beta_{D_w D_b}$ = coefficient for the difference due to sex at weaning regressed on the sex difference at birth,

$\sum_{i=1}^{297} D_{w_i} D_{w_i}$ = corrected cross products for the difference due to sex at weaning and the sex difference at birth,

$\sum_{i=1}^{297} D_{b_i}^2$ = corrected sum of squares for the difference due to sex at birth.

Correlation coefficients were calculated by the use of variance and covariance equations.

Regression coefficients, the difference between means and the difference between selected regression coefficients were tested by the use of the t-test (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Birth Weight

The average birth weights for males and females are presented in Table I. The difference of 3.46 lb. in favor of the bull calves was highly significant ($P < .01$). This difference is less than values previously observed for Hereford calves of 3.9 lb. (Swiger, 1961), 4.0 lb. (Marlowe, 1962), 4.4 lb. (Botkin and Whatley, 1953), 4.5 lb. (Burris and Blunn, 1952), 5.0 lb. (Gregory et al., 1950), 5.2 lb. (Koch et al., 1959), 5.4 lb. (Brinks et al., 1961) and 5.79 lb. (Knapp et al., 1942). However, the observed difference is greater than values reported by Rice et al. (1954) and McCormick et al. (1956) who reported differences of 2.3 and 2.1 lb., respectively. Failure of the observed difference to be as great as most of the reported values can possibly be explained by the facts that 38 percent of the calf records are from two and three year old dams, and that the cows on the low level of winter supplementation gave birth to smaller calves (Pinney, 1963).

The variances presented in Table I suggest that birth weights of bull calves are more variable than birth weights of heifer calves. However, this difference lacked statistical significance. The reports of Gregory et al. (1950), Koch et al. (1959) and Brinks et al. (1961) also suggest that birth weights of bulls are more variable than those of heifers.

A regression analysis was conducted to study the effect of average birth weight of calves on the difference between males and females. The difference between the male and female of each pair was regressed on the average weight of the pair (Figure 1). The regression coefficient of 0.075 (Table II) indicates that as the average weight of the pair increases, the difference between the male and female also increases. In other words, an increase in the average weight of 10 lb. would be accompanied by a 0.75 lb. increase in the difference. However, the coefficient of determination (Table III) indicates that consideration of the average birth weight accounts for only 0.34 percent of the total variation in the difference. This regression coefficient can be represented by the following equation:

$$\text{(I)} \qquad \beta_{da} = \frac{\text{cov}\left(B-H, \frac{B+H}{2}\right)}{V\left(\frac{B+H}{2}\right)} = \frac{2(\sigma_B^2 - \sigma_H^2)}{\sigma_B^2 + \sigma_H^2 + 2\sigma_{BH}}$$

where:

β_{da} = regression of difference on the average,

B = bulls,

H = heifers,

σ_B^2 = variance of bulls,

σ_H^2 = variance of heifers,

σ_{BH} = covariance of bulls and heifers.

It may be noted that the covariance between the difference and the average would be zero if the variances of bulls and heifers were equal. Therefore, this regression coefficient depends on inequality of the variances of bulls and heifers.

TABLE I

EXPRESSIONS OF THE VARIATION ASSOCIATED WITH THE AVERAGE BIRTH WEIGHT OF BULLS AND HEIFERS

Item	Bulls	Heifers	Corrected Heifers
Number of calves	297	297	297
Average birth weight, lb.	75.83	72.36	75.87
Variance	106.22	95.37	105.09
Covariance of bulls and heifers	35.52		
Standard deviation, lb.	10.31	9.77	10.25
Coefficient of variation	13.59	13.50	13.51

TABLE II

REGRESSION COEFFICIENTS AND STANDARD ERRORS FOR BIRTH WEIGHT

Independent Variable	Dependent Variable			
	Difference	Bull	Heifer	Corr. Heifer
Average weight	0.075±.080	1.038±.040	0.961±.040	
Corrected average		1.004±.040		0.996±.040

TABLE III

CORRELATION COEFFICIENTS AND COEFFICIENTS OF DETERMINATION OF VARIABLES ASSOCIATED WITH BIRTH WEIGHTS

	Difference between Bulls & Heifers	Weight of Heifers	Weight of Bulls
Average weight	0.058[a] 0.34 [b]	0.811 65.77	0.832 69.22
Weight of heifers			0.352 12.39

[a]Correlation coefficient. [b]Coefficient of determination.

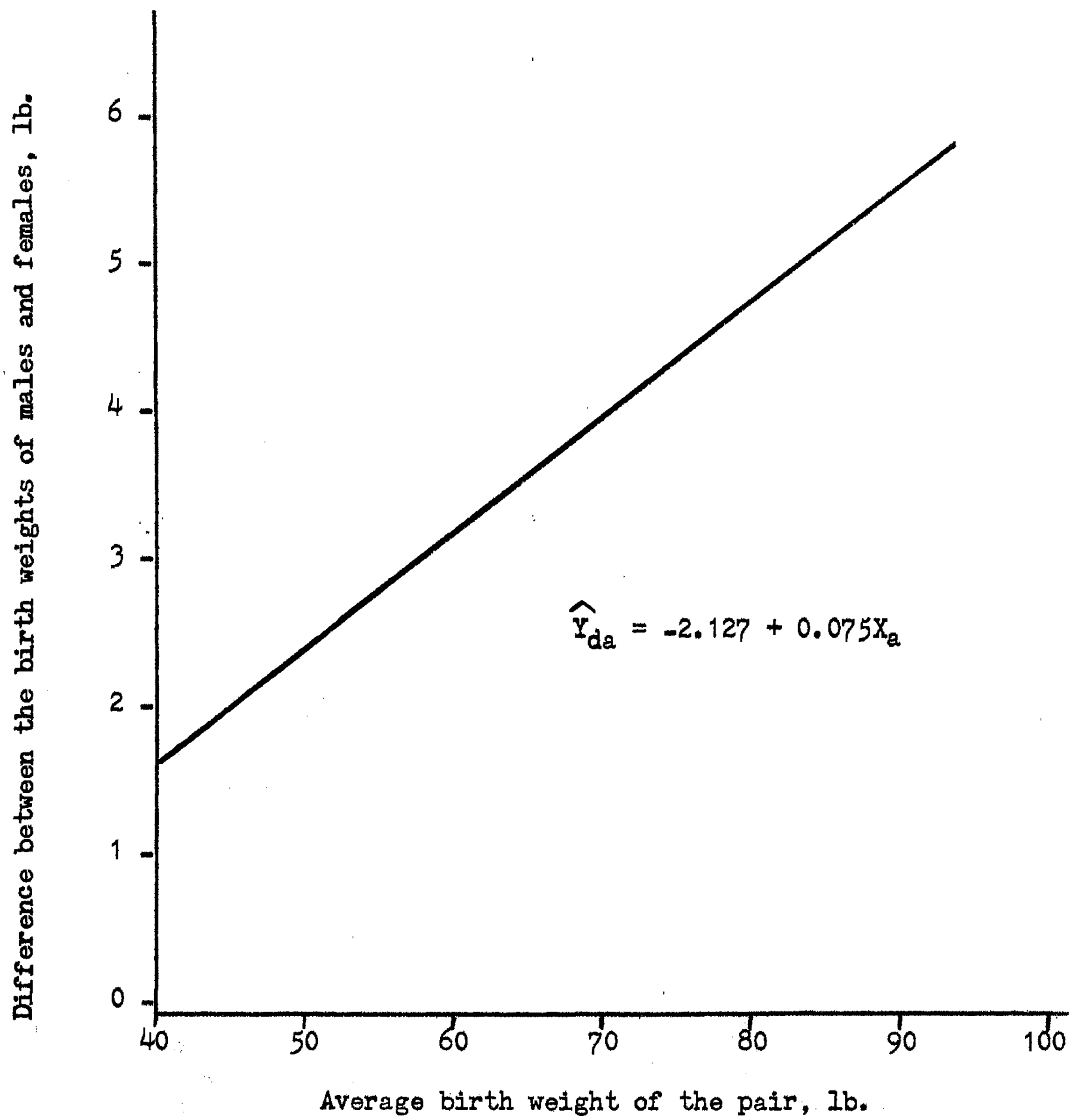

Figure 1. Regression of the difference in birth weight between male and female calves of each pair on the average birth weight of the pair.

The effect of the average birth weight on the difference in birth weight attributable to sex was also studied by regressing the weight of each sex on the average weight of the pair (Figure 2). The regression coefficients (Table II) are 1.038 for males on the average and 0.961 for females on the average. Both of these coefficients are highly significant ($P < .01$). These coefficients may be represented by the following equations:

$$\beta_{ba} = \frac{\text{cov}\,(B, \frac{B+H}{2})}{V\,(\frac{B+H}{2})} \text{ and } \beta_{ha} = \frac{\text{cov}\,(H, \frac{B+H}{2})}{V\,(\frac{B+H}{2})}$$

which simplify to:

$$\beta_{ba} = \frac{2(\sigma_B^2 + \sigma_{BH})}{\sigma_B^2 + \sigma_H^2 + 2\sigma_{BH}} \text{ and } \beta_{ha} = \frac{2(\sigma_H^2 + \sigma_{BH})}{\sigma_B^2 + \sigma_H^2 + 2\sigma_{BH}}$$

where:

β_{ba} = regression coefficient of the weight of the male on the average,

β_{ha} = regression coefficient of the weight of the female on the average.

Thus, the difference between these two regressions is:

$$\text{(II)} \qquad \beta_{ba} - \beta_{ha} = \frac{2(\sigma_B^2 - \sigma_H^2)}{\sigma_B^2 + \sigma_H^2 + 2\sigma_{BH}}$$

Therefore, by comparison of equations I and II it is evident that the difference between these two regression coefficients estimates the same parameter as the regression coefficient for the difference on the average. The difference between β_{ba} and β_{ha} of 0.077 indicates that the weight

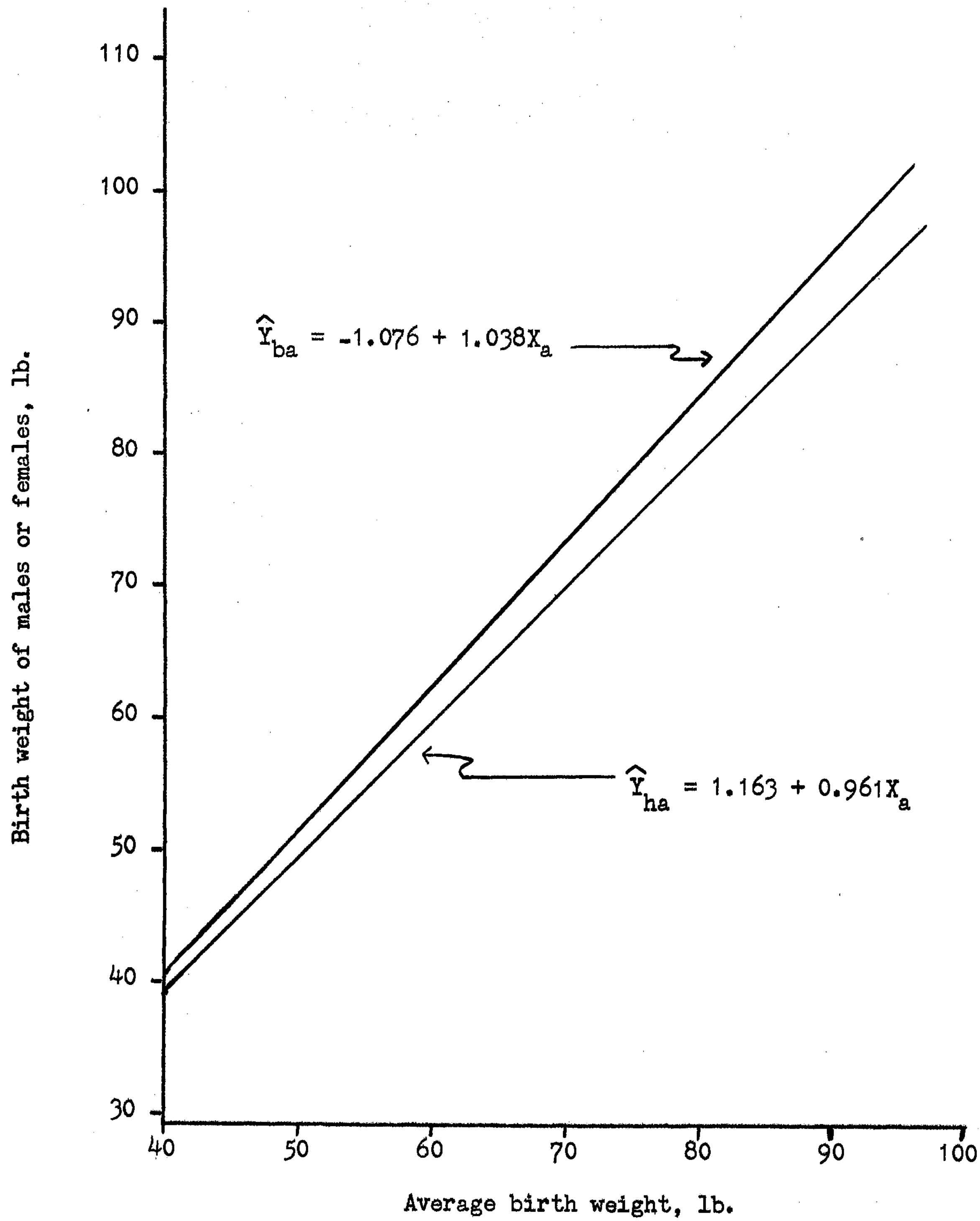

Figure 2. Birth weights of the male and female of each pair regressed on the average weight of the pair.

of males increases with the average at a greater rate than does the weight of females. However, this difference was not statistically significant.

Method of Correction

Both additive and multiplicative corrections are in general use for correcting birth weights for the effect of sex. Additive corrections change the mean without changing the variance; whereas, multiplicative correction factors not only alter the mean but also change the variance by the product of the square of the factor involved. Additive corrections add the same amount to all weights whereas multiplicative factors correct on the basis of the existing weight. Additive and multiplicative factors affect values near the mean in the same manner, but differ in their effects on extreme values. The multiplicative factor most generally used is the ratio of the mean weight of the males to the mean weight of the females. The weights of the females are then multiplied by this ratio to adjust them to a male equivalent.

The reports of Koch et al. (1959) and Brinks et al. (1961) suggest that if the standard deviations of males and females are equal, an additive correction should be used and if the coefficients of variation are equal, a multiplicative factor should be employed to correct for the effect of sex on birth weight. In other words, if the standard deviations are equal no adjustment of the variance is required; thus, an additive factor is appropriate as it alters the mean and not the variance. However, if the standard deviations are not equal, the variances as well as the means are unequal; therefore, a multiplicative factor should be used so that both the mean and variance will be adjusted.

Since the coefficients of variation were more nearly equal than the standard deviations (Table I), a multiplicative factor was used to adjust the weights of the heifers to a bull equivalent. This factor, $(\frac{\text{mean weight of bulls}}{\text{mean weight of heifers}})$, was 1.048. This ratio is comparable to previously reported values of 1.076 (Koch et al., 1959) and 1.05 (Seebeck and Campion, 1964), and values of 1.032, 1.071 and 1.057 calculated from data presented by Rice et al. (1954), Brinks et al. (1961) and Marlowe (1962), respectively. The values for corrected and uncorrected data presented in Table I indicate that this method of correction tended to equalize both means and variances. The mean difference between males and females was reduced from 3.46 to -.04, and the ratio of the variance of males to the variance of females was reduced from 1.113 to 1.010. This suggests that the multiplicative factor is a useful method for correcting for sex difference in birth weights even for data with the wide range of birth weights involved in this study.

Further evidence of the adequacy of the multiplicative correction procedure may be gained by examination of Figures 2 and 3. These illustrations indicate that correcting the female of each pair to a male equivalent decreased the difference between the slopes of the lines for males and females regressed on the average. The difference between the slopes of the lines was reduced from 0.077 to 0.008.

Weaning Weight

The average 210 day adjusted weaning weights of steers and heifers presented in Table III indicate that steer calves were 25.35 lb. heavier than heifer calves. This highly significant ($P < .01$) difference compares favorably with results obtained with similar calves of analogous

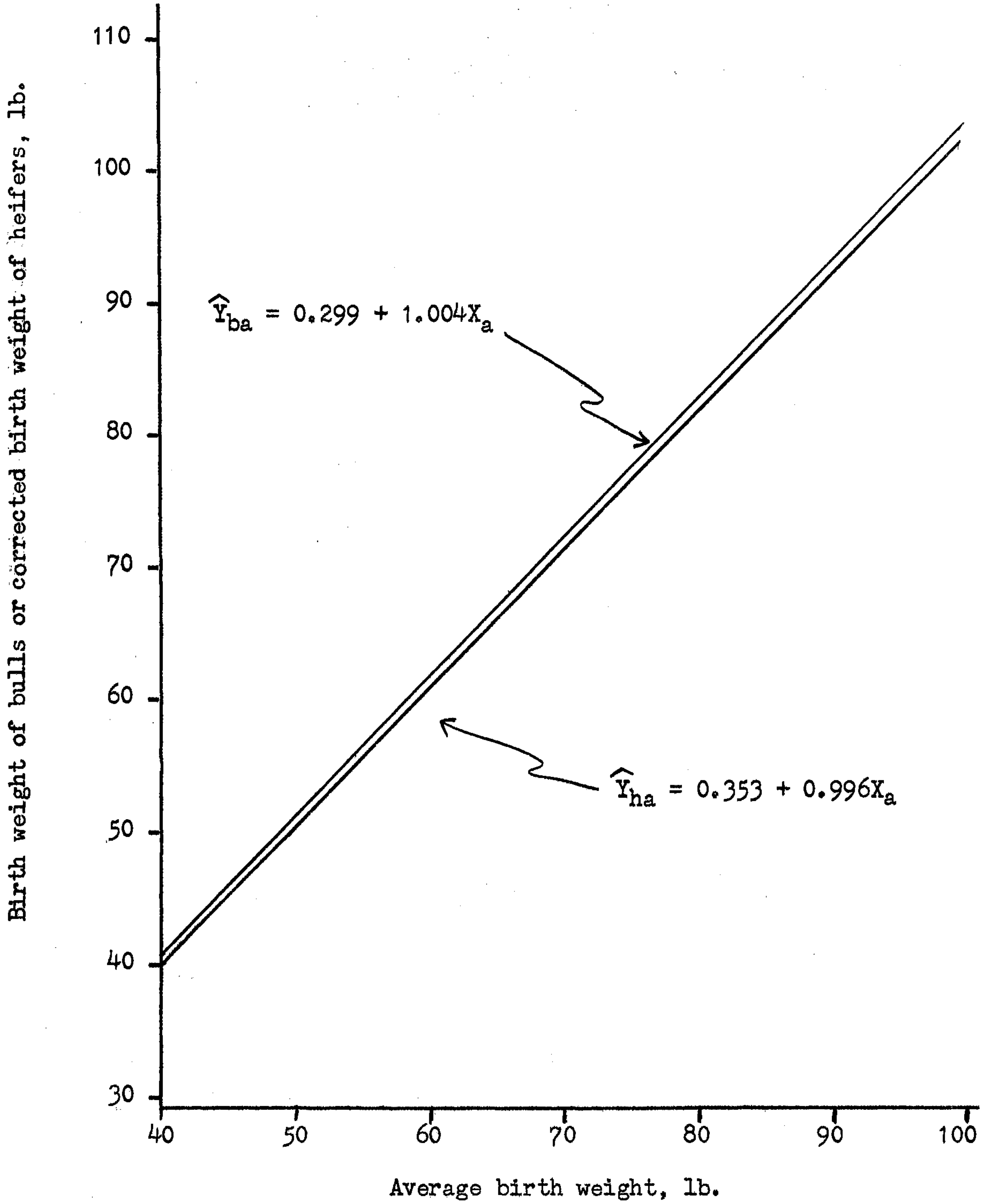

Figure 3. Birth weight of the bull and corrected birth weight of the heifer of each pair regressed on the corrected average weight of the pair.

age reported by Botkin and Whatley (1953) and Rice et al. (1954) who reported differences between steers and heifers of 24.6 and 28.8 lb., respectively. However, other studies with similar cattle of comparable age have suggested differences both smaller and larger than the difference observed in this study. A difference of 32 lb. was reported by Koger and Knox (1945). Evans et al. (1955) observed a difference of 17 lb. between steers and heifers in their study. In contrast, a report by McCormick et al. (1956) indicated that heifers were 12 lb. heavier than steers at weaning.

Variances for steers and heifers presented in Table III suggest that weaning weights of steers were more variable than those of heifers. However, this difference lacked statistical significance. Results obtained by Gregory et al. (1950), Brinks et al. (1961), Creek and Nestel (1964) and Cundiff (1966) have also suggested that weaning weights of steers are more variable than weaning weights of heifers.

The influence of the average weaning weight of calves on the difference in weaning weight attributable to sex was studied by the use of regression analysis. For this analysis, the difference between the steer and heifer of each pair was regressed on the average weight of the pair (Figure 4). The regression coefficient of 0.063 (Table V) indicates that as the average weight of the pair increases the difference between the weight of the steer and heifer also increases. For example, an increase in the average weight of 100 lb. would be accompanied by a 6.30 lb. increase in the sex difference. However, the coefficient of determination presented in Table VI indicates that the average weaning weight accounted for only a 0.31 percent reduction in the sum of squares of the sex difference. Several reports have presented

TABLE IV

EXPRESSIONS OF THE VARIATION ASSOCIATED WITH THE AVERAGE WEANING WEIGHT OF STEERS AND HEIFERS

Item	Steers	Heifers	Corrected Heifers
Number of calves	297	297	297
Average Weaning Weight, lb.	454.71	429.39	454.69
Variance	3831.26	3484.13	3909.95
Covariance of steers and heifers	1937.95		
Standard deviation, lb.	61.88	59.03	62.53
Coefficient of variation	13.61	13.75	13.75

TABLE V

REGRESSION COEFFICIENTS AND STANDARD ERRORS FOR WEANING WEIGHTS

Independent Variable	Dependent Variable			
	Difference	Steer	Heifer	Corr. Heifer
Average weight	0.063±.064	1.031±.032	0.969±.032	
Corrected average		0.995±.032		1.014±.032
Difference at birth	2.333±.069			

TABLE VI

CORRELATION COEFFICIENTS AND COEFFICIENTS OF DETERMINATION OF VARIABLES ASSOCIATED WITH WEANING WEIGHT

	Difference between Bulls & Heifers	Weight of Heifers	Weight of Bulls
Average weight	0.056[a] 0.31 [b]	0.868 75.34	0.881 77.62
Weight of heifers			0.530 28.09

[a]Correlation coefficient.
[b]Coefficient of determination.

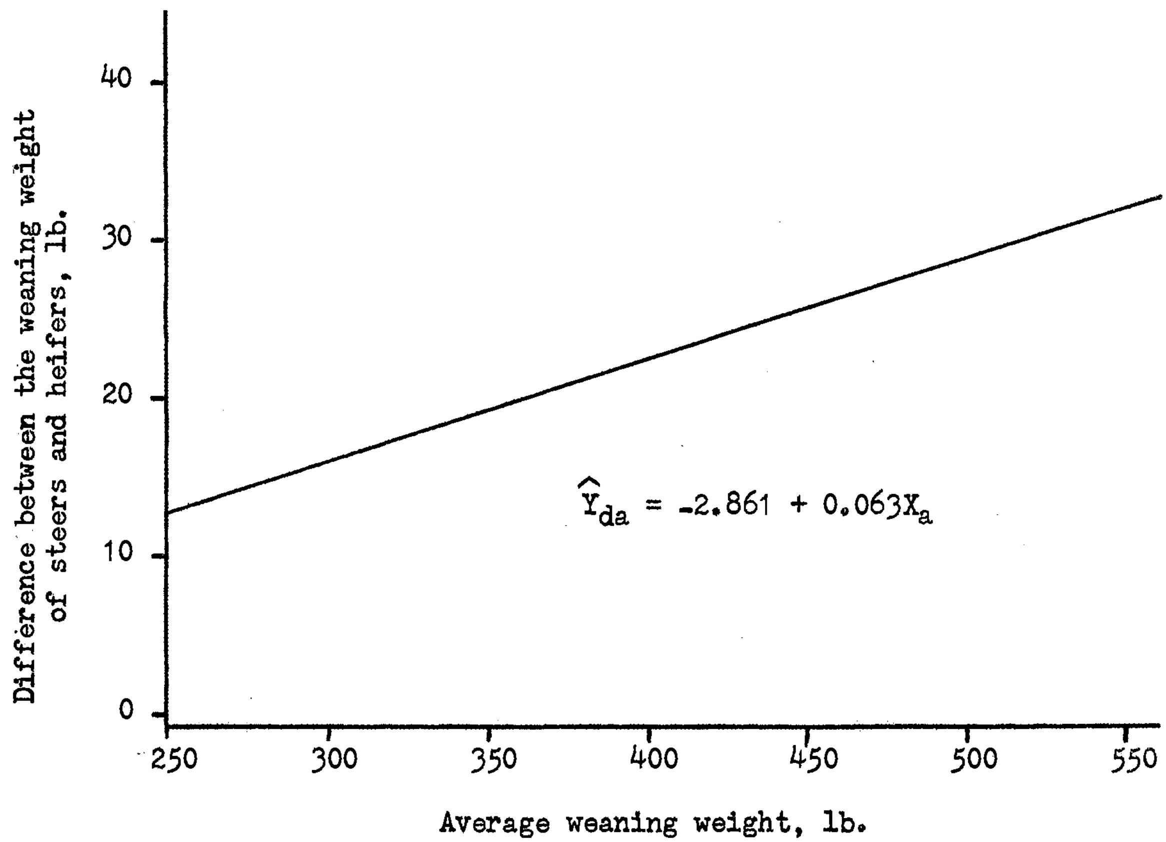

Figure 4. Difference between the weaning weight of the steer and heifer of each pair regressed on the average weight of the pair.

data which indicates that the difference between steers and heifers is greater in groups of calves that have a greater average weaning weight (Clum et al., 1956; Rollins and Wagnon, 1956; Vernon et al., 1964). The regression coefficient for the difference between steers and heifers on the average can be expressed by the following equation:

$$\text{(V)} \qquad \beta_{da} = \frac{\text{cov}\left(S-H, \frac{S+H}{2}\right)}{V\left(\frac{S+H}{2}\right)} = \frac{2(\sigma_S^2 - \sigma_H^2)}{\sigma_S^2 + \sigma_H^2 + 2\sigma_{SH}}$$

where:

β_{da} = regression coefficient for the difference due to sex regressed on the average weight,

S = the weight of steers,

H = the weight of heifers,

σ_S^2 = variance of steers,

σ_H^2 = variance of heifers,

σ_{SH} = covariance between steers and heifers.

Examination of this equation indicates that if the variances of steers and heifers were equal the covariance between the sex difference and the average weight would be zero. Thus, this regression coefficient is dependent upon unequal variances of steers and heifers.

The possibility of a dependency of the sex difference on the average weaning weight was investigated by a second procedure. In this analysis, the weight of each sex of the pair was regressed on the average weight of the pair (Figure 5). The coefficients (Table V) were 1.031 for steers regressed on the average and 0.969 for heifers regressed on the average. Both of these coefficients were statistically highly significant ($P < .01$). The difference between the slopes of these lines,

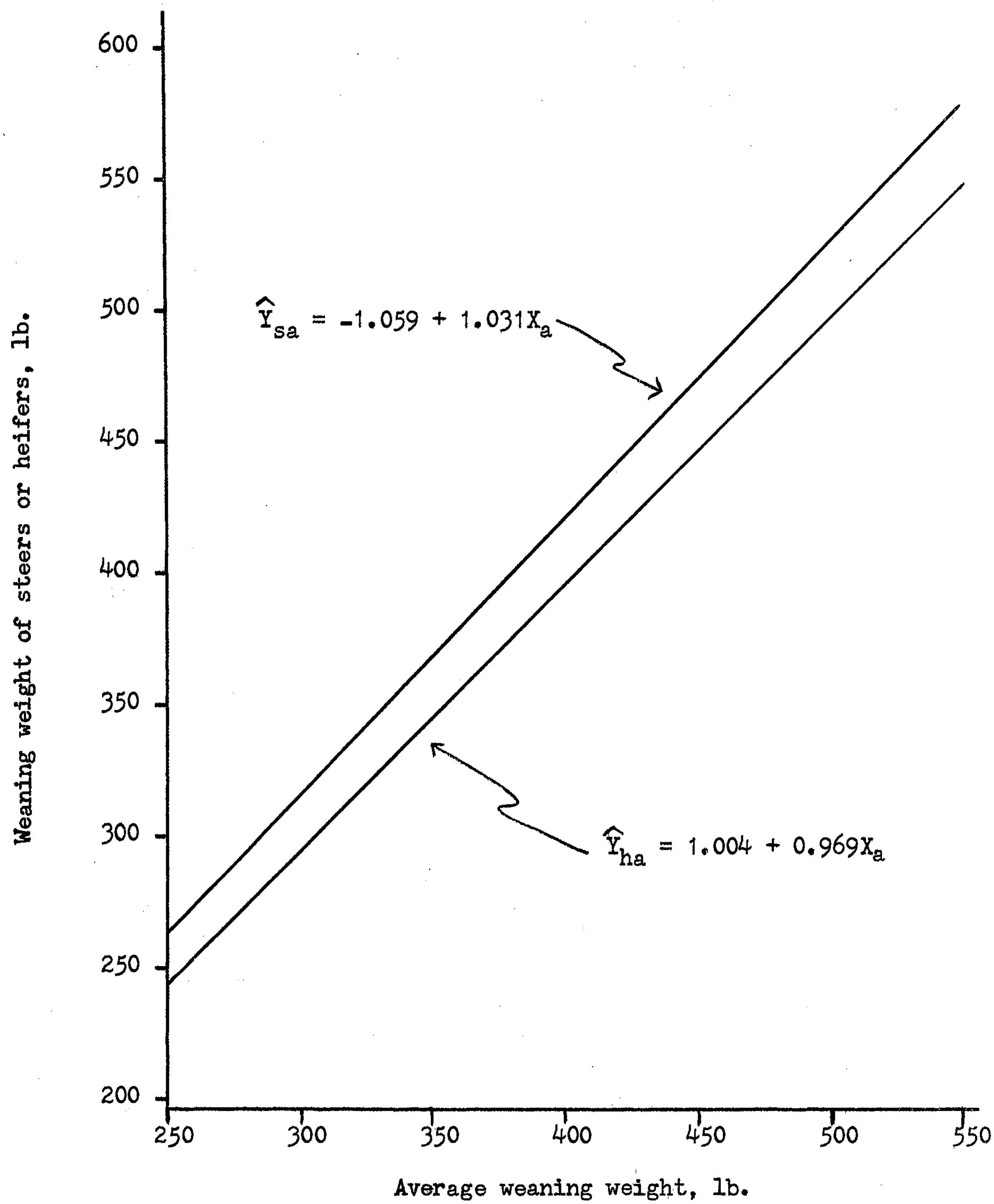

Figure 5. Weaning weight of the steer and heifer of each pair regressed on the average weight of the pair.

0.062, suggests that the weight of the steers increased with the average weight at a greater rate than did the weight of the heifers. This difference approached significance ($P > .05$). These regression coefficients may be represented by the following expressions:

$$\beta_{sa} = \frac{\text{cov}\ (S,\ \frac{S+H}{2})}{V(\frac{S+H}{2})} \quad \frac{2(\sigma_S^2 + \sigma_{SH})}{\sigma_S^2 + \sigma_H^2 + 2\sigma_{SH}}$$

and

$$\beta_{ha} = \frac{\text{cov}\ (H,\ \frac{S+H}{2})}{V(\frac{S+H}{2})} = \frac{s(\sigma_H^2 + \sigma_{SH})}{\sigma_S^2 + \sigma_H^2 + 2\sigma_{SH}}$$

where:

β_{sa} = regression coefficient for weight of the steer regressed on the average weight of the pair,

β_{ha} = regression coefficient for weight of the heifer regressed on the average weight of the pair.

Thus, the difference between these two regression coefficients is as follows:

(VI) $$\beta_{sa} - \beta_{ha} = \frac{2(\sigma_S^2 - \sigma_H^2)}{\sigma_S^2 + \sigma_H^2 + 2\sigma_{SH}}$$

Examination of equations V and VI indicates that this difference should be equal to the coefficient for the sex difference regressed on the average.

The dependency of the sex difference at weaning on the difference due to sex at birth was studied by the use of regression analysis. The regression of the difference between steers and heifers at weaning on the difference at birth is presented in Figure 6. The coefficient of 2.333, which was highly significant ($P < .01$), suggests that the difference

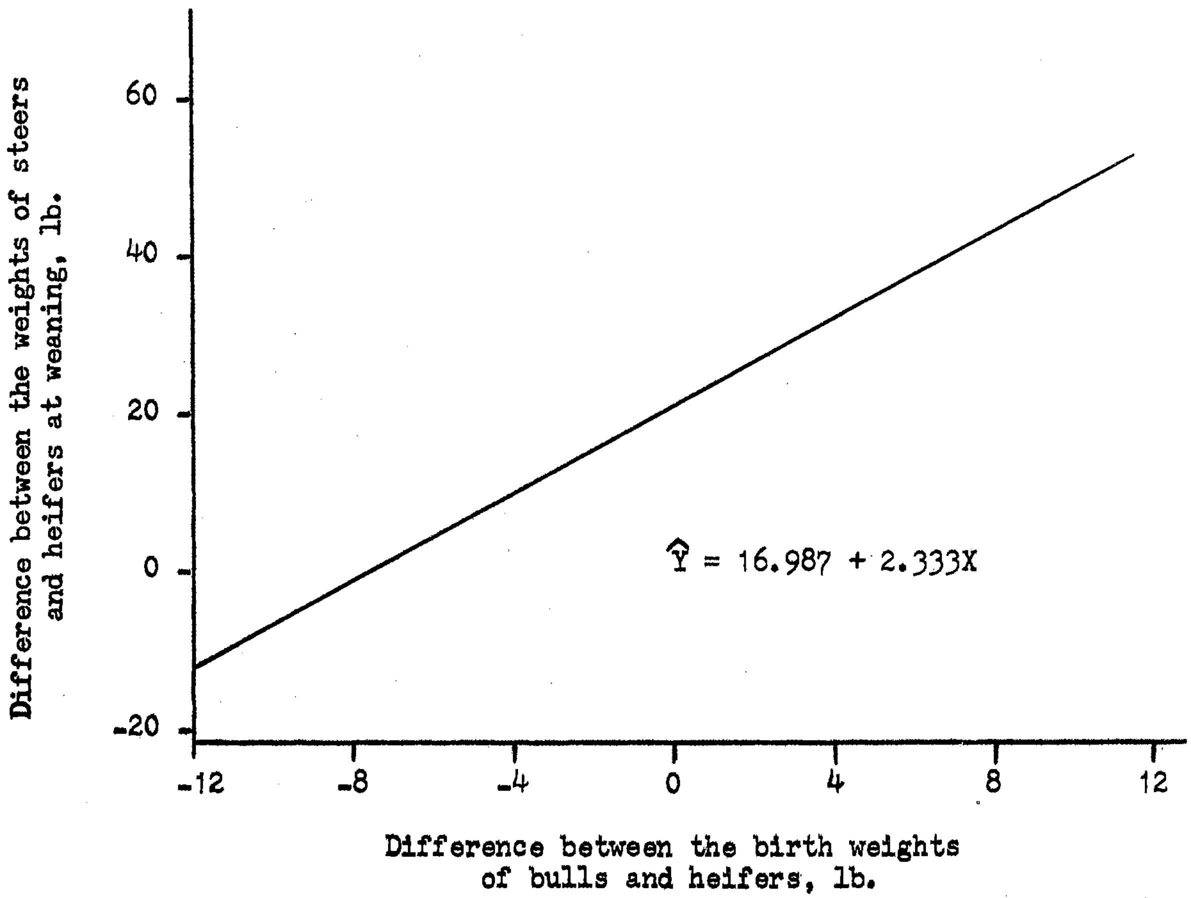

Figure 6. Difference between the weaning weights of steers and heifers regressed on the difference in birth weights.

at weaning is greater for the pairs in which there was a greater difference at birth. In other words, the difference between steers and heifers at weaning increased by 2.33 lb. for each 1 lb. increase in the difference between bulls and heifers at birth. The difference in birth weight due to sex accounted for 21.0 percent of the variation in the sex difference at weaning.

Method of Correction

The effects of additive and multiplicative correction procedures have been discussed in the section pertaining to birth weight.

Koch *et al.* (1959) and Brinks *et al.* (1961) have suggested that an additive correction should be used if the standard deviations are equal and a multiplicative correction should be used if the coefficients of variation are equal. In as much as the coefficients of variation were more nearly equal than the standard deviations (Table IV), a multiplicative correction was considered more appropriate than an additive correction for correcting these data for the effect of sex. The ratio of the average weaning weight of steers to the average weaning weight of heifers was 1.059. The weight of the heifers were multiplied by this ratio to adjust them to a steer equivalent. This ratio compares favorably with values previously reported of 1.08 (Clum *et al.*, 1956), 1.073 (Koch *et al.*, 1959) and ratios of 1.062 and 1.076 calculated from the data presented by Brinks *et al.* (1961) and Creek and Nestel (1964), respectively. However, greater ratios have been reported by Kiefer (1959) and Vernon *et al.* (1964) who recorded values of 1.112 and 1.114, respectively.

This method of correction equalized the average weaning weight of steers and heifers (Table IV). The original difference between steers and heifers was 25.35 lb. and the difference after the weights of the heifers were adjusted to a steer equivalent was 0.02 lb.

Variances presented in Table IV indicate that this correction procedure over corrected the variance of females. The ratio of the variance of males to the variance of females was changed from 1.10 to 0.98. These results indicate that the correction procedure does not completely equalize the variances of data with as wide a range of weaning weights as involved in this study. Brinks _et al._ (1961) indicated that even though the multiplicative factor was superior to the additive factor, it did not completely equalize the variances of steers and heifers in their data.

Fitted regression lines for the weight of the steer and heifer of each pair on the average of the pair presented in Figure 5 for the uncorrected data and Figure 7 for the corrected data illustrate the effect of this correction procedure on the difference between males and females at weaning. The difference between β_{sa} and β_{ha} was reduced from 0.062 to -.019. Therefore, lending further evidence to the fact that the multiplicative factor tended to over correct the variance of the heifers as this difference between the slopes of these lines depends on the difference between the variance of steers and heifers (Equation VI).

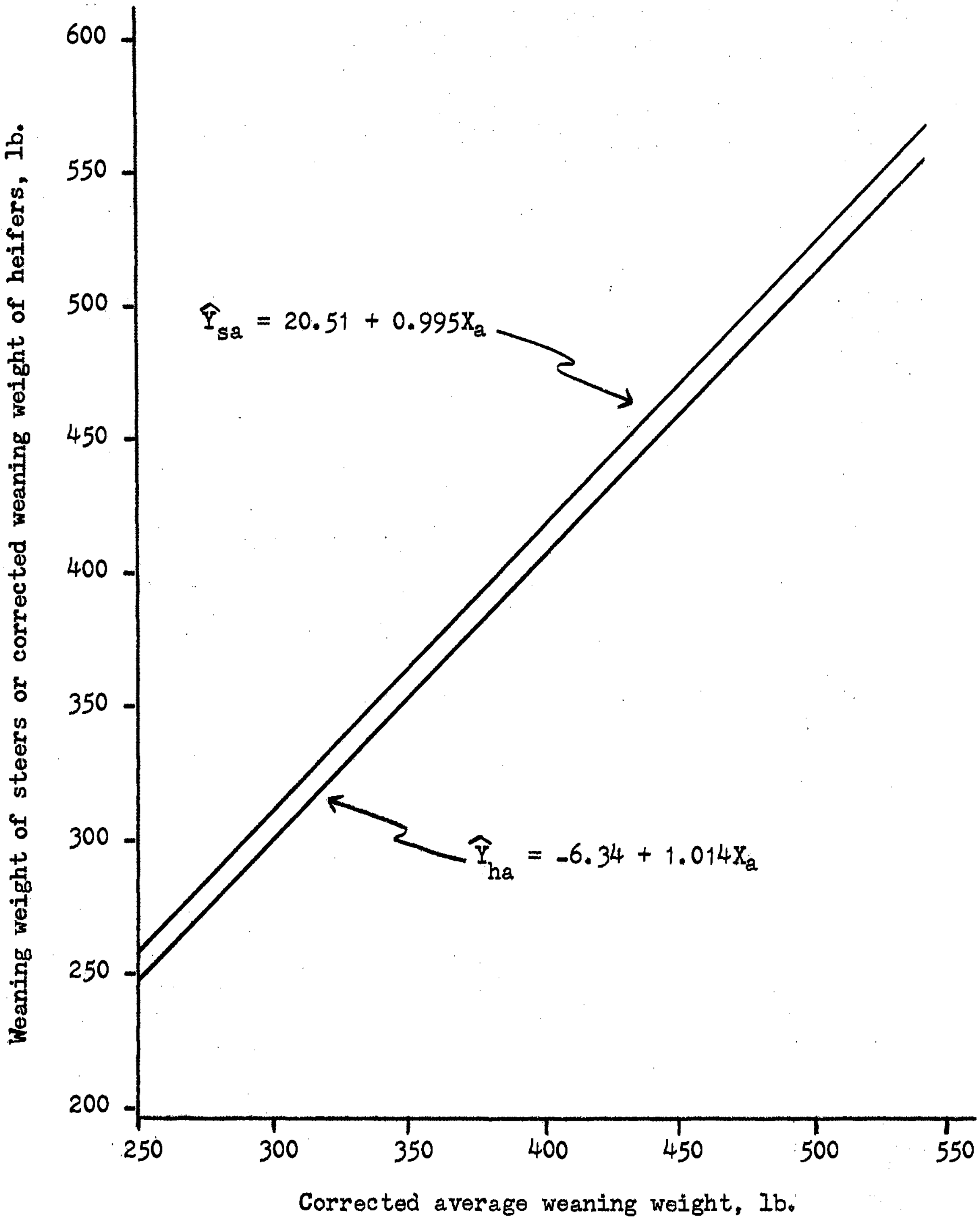

Figure 7. Weaning weight of the steer and corrected weaning weight of the heifer of each pair regressed on the average weight of the pair.

SUMMARY

The data involved in this study were collected during the ten year period from 1954 through 1963 from level of winter feeding studies conducted on the Fort Reno Experiment Station at El Reno, Oklahoma. The effect of sex upon birth and weaning weights of beef calves was studied. All calves were grouped on the basis of year of birth, age of dam, treatment of dam and sire of the calf. All groups that did not contain one calf of each sex were discarded. One calf of each sex was selected at random from each group. After this pairing procedure was applied, there were a total of 297 pairs of calves available for analysis.

Bull calves were 3.46 lb. heavier than heifer calves at birth, and steers were 25.35 lb. heavier than heifers at a standard weaning age of 210 days. These differences were highly significant ($P < .01$). Males were more variable than females both at birth and weaning. However, these differences lacked statistical significance.

The effect of the average birth and weaning weight on the difference in these weights that is attributable to sex was studied. The difference in birth and weaning weights due to sex was regressed on the respective average weights. The regression coefficients were 0.075 for birth weight and 0.063 for weaning weight. However, the average weight only accounted for approximately 0.30 percent of the total variation in the sex difference at birth and weaning.

The weight of the male and female of each pair was regressed on the average weight of the pair. For birth weight the coefficients for

bulls regressed on the average was 1.038 ($P < .01$) and for heifers on the average was 0.961 ($P < .01$). For weaning weights the coefficients were 1.031 ($P < .01$) for steers regressed on the average and 0.969 ($P < .01$) for heifers on the average. The differences between the regression coefficients for males and females indicate that the weight of the male increases with the average weight at a faster rate than does the weight of the heifer. However, these differences lacked statistical significance ($P > .05$).

The data were corrected for the effect of sex on birth and weaning weight by use of multiplicative factors. These factors were derived by the ratio of the average weight of males to the average weight of females. The weights of the females were then multiplied by this ratio to correct the female weight to a male equivalent. These factors were 1.048 for birth weight and 1.059 for weaning weight. The correction procedure tended to equalize both means and variances for birth weight. However, this procedure equalized the means but over corrected the variance by a small amount for weaning weight.

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