Correction Factors for Adjusting Weights of Range Calves to a Constant Age

Christian Alfred Dinkel

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CORRECTION FACTORS FOR ADJUSTING

WEIGHTS OF RANGE CALVES TO A CONSTANT AGE

By

Christian Alfred Dinkel

A thesis submitted
to the faculty of South Dakota
State College of Agriculture and Mechanic Arts
in partial fulfillment of the requirements
for the degree of
Master of Science

August 1949
This is to certify that, in accordance with the requirements of South Dakota State College for the Master of Science Degree, Mr. Christian A. Dinkel has presented to this committee three bound copies of an acceptable thesis, done in the major field; and has satisfactorily passed a two-hour oral examination on the thesis, the major field, Animal Husbandry, and the minor field, Biochemistry.

August 20, 1949
Date
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INTRODUCTION

In experimental beef cattle breeding work and commercial beef production it is desirable to know comparative weights of calves at a given age, usually at weaning age of around 200 days. Some workers have gone to considerable trouble weighing all calves at 200 or 205 days regardless of work involved. A few have weaned calves at a constant weight such as 500 pounds and made their comparisons on gain per day to test weight. These methods are usually impractical in herds kept under corn-belt conditions and practically impossible in herds maintained on western or north-central ranges. Weaning at a constant weight or age on the range would mean the rounding up and bringing in of the herd either weekly or bi-weekly from September until late November or December. Such excessive handling would have an effect on much of the experimental data being kept on the herd.

Swine and lamb producers have solved the problem of comparing animals of different ages by developing correction factors for correcting weights to a standard age. Sets of factors commonly used in swine production are (1) Factors for correcting to a standard weaning age, usually 56 days, (2) Factors correcting weights to 154 days, and (3) Factors correcting weights to 180 days or final weight. These factors enable the comparison of pigs of different ages at various stages of production with a minimum of labor and disturbance of the animals. Sheepmen commonly correct weaning weights of lambs to 20 weeks of age.

It is the purpose of this investigation to develop a set of correction factors that can be used to adjust weights of calves of different
ages to a standard age, thus affording a valid means of comparing calves at weaning without weighing each calf at a constant age.

Such correction factors should have many uses. The purebred breeder could use them to determine which animals should be used heavily in building his breeding herd. In experimental work they could be used in selecting calves for bull testing, progeny testing and feeding trials. They would be especially useful in estimating productivity of cows.

Correction factors should prove more useful for beef cattle producers than they have for swinemen, since the time between weaning and reproduction is greater in cattle. If the very young calves can be properly evaluated, they will have sufficient time to mature before they are bred for first calves. In swine, however, the very young gilts do not have sufficient time to mature before breeding.
REVIEWS OF LITERATURE

Bywaters and Willham (1935), working with limited data on swine, developed a formula to estimate growth rate of pigs of market age. Straight lines were fitted to three growth curves from the nineteenth through the thirty-second week. The straight lines were then extended to the age axis. The intercepts of these lines were all close to 65 days. The authors found that by dividing the pig's weight by his age less sixty-five days, a usefully accurate estimate of growth rate could be obtained. This method corrects for differences in age at weighing, but does not allow for differences in feeding and management.

Whatley and Quaife (1937) developed a method of adjusting weights of pigs to a standard age of 56 days. The authors patterned their work after that of Bywaters and Willham. They eliminated the differences due to feeding and management by computing the regression of weight on age on an intra-farm basis. Data collected in 1936 and 1937 were used, and after combining the two, the intra-farm regression coefficient was 0.72 pounds per day, the mean weight 30.3 pounds and the mean age 58 days. The regression line intercepted the age axis at 14.9 days. This intercept was then used in the formula:

\[
\text{corrected weight} = \text{actual weight} \times \frac{\text{standard age - 15}}{\text{actual age - 15}}
\]

From this formula, a table of factors was calculated for adjusting from any age to 56 day weight. The factor for age is multiplied by the actual weight to obtain the corrected weight for 56 days of age. The authors caution that correcting to weights at ages very far from
56 days will introduce errors due to the changes of slope of the normal growth curve.

Similar work with lambs was carried on by Phillips and Brier (1940) of the United States Department of Agriculture. They compared the accuracy of estimating weights first by weekly gains and second by using the age intercept. The formula used for the first method was \( \frac{Z - B}{X} \cdot 20 + B = Y \), where \( Y \) equals estimated weight, \( Z \) equals actual weight, \( B \) equals birth weight, \( X \) equals actual age and 20 is the constant age of 20 weeks. The formula for the second method was \( \frac{Z}{(X - A)} = Y \), where \( A \) equals the age intercept and the other symbols are the same as above. In all comparisons the second method more nearly approached the actual weight at 20 weeks than did the first.

Working with beef cattle Koger and Knox (1945) developed a method of adjusting weaning weight for age of calves. Weights were classified by year, sex, and age of dam, and regression of weight on age calculated. Regression of weight on age within subgroups was 1.33 pounds per day. It was found necessary, however, to use a variable regression coefficient due to the fact that the coefficient was positively correlated with the average weight of the group from which it was calculated. The form equation used was \( W = w + db \) where \( W \) is the corrected weight, \( w \) the weight at weaning or actual weight, \( d \) is the standard age minus the age at weighing and \( b \) the regression coefficient. The average weaning age of 205 days was used as standard age in these calculations. This method differs from the above mentioned methods in that the regression coefficient changes with variation in the weight of animals at any given age. The advantages claimed for this method are: (1) the form
equation is true whether or not the lines of regression have a common point. (2) a mathematical expression of the relationship of regression and weight at any age can be calculated. The authors state that when animals varying in age are weighed at one time, regression of weight on age reflects the influence of date of birth on growth rate if such influence is present. Thus it is estimated what the weight would have been if birth date had been 205 days previous to the day of weighing.

Lush and Kincaid (1943) developed a method of estimating 154 day weights of pigs based on a quadratic equation. This method differs basically from the linear methods in that it assumes the increase in rate of gain to be constant over the period whereas the linear methods assume the rate of gain to be constant. Under the above assumption the authors set up the first derivative and integrated to obtain the equation. The following data were taken from a normal growth curve for pigs for use in the equation: The average pig gained 1.39 and 1.75 pounds per day at 126 and 182 days of age, respectively, and the average weight at 154 days of age was 142.5 pounds. Their first derivative was:

\[
\frac{Y - 1.75}{X - 182} = \frac{1.75 - 1.39}{182 - 126}
\]

where \(Y\) is daily gain in pounds and \(X\) is age in days. After integration and substitution of \(W = 142.5\) when \(X = 154\) the authors got the equation:

\[
W = .0032143X^2 + .58X - 23
\]

which gives the estimating equation:

\[
W = Z \frac{142.5}{.0032143X^2 + .58X - 23}
\]

where \(Z\) is the actual weight at age \(X\). Factors were set up by solving the fraction for \(X = \) each day of age in the range. This equation was
found to fit quite well from 100 to 200 days, but the authors caution that it should be used only between 135 and 175 days of age until confirmed by further research.

The calves used in this study were the weekly weights taken from birth to weaning on 200 calves. These calves were raised on the range at the Cottonwood Range Field Station and represent the 1962-1963 herd. They were fed exclusively dried and ensiled grasses and different wintering regions were being compared.

The calves in this investigation included all calves from all the test lots. The calves from the areas on the quiet grazed pastures gained slightly less than those from areas on the over-grazed pastures. A five year analysis of the results of the grazing experiment indicates the greatest difference in calf gains between quiet and over-grazing to be 0.9 pounds per day from birth to weaning.

The majority of the calves were born to heifers in April and May with few scattered births in March and June. They were raised with daily visits in a reverse two-thirds lore, one-third over; one-third over; one-third verbal, and one-third verbal. They received no food other than milk. The average gain for all of the calves for the period 1962 through 1965 was 50 pounds. The calves were not measured as soon as they were born. First of all, the gains for these animals were 180 days old. The heifer's average weight was 375.7 pounds.
SOURCE OF DATA

The data used in this study were the monthly weights taken from birth to weaning on 297 calves. These calves were raised on the range at the Cottonwood Range Field Station and represent the 1942-1948 calf crops inclusively. The dams of these calves were being used in wintering and summer grazing experiments in which effects of under, over and normal grazing and different wintering rations were being compared. The calves in this investigation included all calves from all the test lots. The calves from the cows on the under grazed pastures gained slightly less than those from cows on the over grazed pastures. A five year summary of the results of the grazing experiment indicates the greatest difference in calf gains between under and over grazing to be .09 pounds per day from birth to weaning.

The majority of the calves were born in April and May with a few scattered births in March and June. They were raised with their dams on a range consisting of one-third Blue Grama Grass, one-third Buffalo Grass, and one-third Western Wheat Grass. They received no feed other than milk and grass. The average annual rainfall at the station for the period 1942 through 1948 was 14.6 inches. The calves were all weaned as near to November first as was possible. The average weaning age was 185 days and the average weaning weight was 379.7 pounds.
ANALYSIS OF DATA AND RESULTS

Growth Curve

The growth curve for the calves studied is presented in Figure I. This was calculated by averaging all weights for each day of age. The daily averages are shown in the figure as dots. Ten day averages were also plotted for ease in free-hand fitting of the curve. They are indicated with an x. A general inspection of the curve appears to indicate that the growth from birth to 155 days of the range calves studied follows a nearly straight line, and thereafter, increased at a decreasing rate. If this is true, correction factors calculated from linear regression lines on the almost straight portions of the curve would adequately adjust weaning weights for comparing range calves of different ages.

Linear Regression

A set of correction factors was calculated for each of the periods, birth to 155 days, and 155 days to 225 days. The method used in calculating these correction factors was similar to that used by Whatley and Quaife (1937) and Phillips and Erier (1940).

First, a linear regression was calculated on a within calf basis for each of the age ranges (Snedecor 1946). Then the intercept of these regression lines with the age axis was calculated for use in the correction equation:

\[ Y = \frac{(A - I)}{(X - I)} \]

where \( Y \) is the corrected weight, \( A \) is the standard age, \( I \) is the inter-
Figure 1. Growth Curve for Range Calves from Birth to 225 Days
cept, and \( X \) is the actual age in days. The standard ages used in the two sets of factors were 155 days and 190 days. The 190 days was chosen because it was the average weaning age for the last three years of the period and will likely be the average weaning age on the experimental range stations of South Dakota State College. The 155 days was used because it marked the end of the approximately straight line portion of the first part of the growth curve. With the two sets of factors the weight of a rather young calf can be adjusted to 155 days of age, and then adjusted further to 190 days if such seemed advisable.

**Quadratic Equation**

In addition to the two sets of factors already discussed, a third was calculated by using the method presented by Lush and Kincaid (1943). The factors were calculated for the period from 155 to 225 days. This set of factors was calculated from a quadratic equation for that portion of the curve by setting up the first derivative and integrating. The following data were taken from the growth curve for use in the estimating equation: Average growth rate at 155 days of age was 1.7 pounds per day, average growth rate at 225 days was 0.7 pounds per day, and average weight at 190 days was 403.4 pounds. The first derivative thus appeared as:

\[
\frac{X - 0.7}{X - 225} = \frac{0.7}{225 - 155} = \frac{dW}{dx}
\]

where \( Y \) is daily gain in pounds, \( X \) is age in days, and \( W \) is weight.

Integrating this and solving for the constant by substituting \( W = 403.4 \) when \( X = 190 \) gives:

\[
W = 3.914283X - 0.00714285X^2 - 82.45689
\]
and the adjusting equation is:

\[ W = \frac{403.4}{3.914283X - 0.00714285X^2 - 82.45689} \]

where \( Z \) is actual weight at age \( X \). Factors were calculated by substituting the ages between 155 and 225 for \( X \) in the fraction. Thus to obtain the estimated weight select the factor for the day of age of the calf on the day it was weighed and multiply it times the actual weight on that day.
Results

Table I contains the factors for correcting ages up to 155 days. The intercept, \(-40\) days, obtained by extending the regression line to the X axis, was substituted in the formula

\[
\text{Standard age} - \text{Intercept} = \text{Actual age} - \text{Intercept}
\]

to obtain these factors. The estimated weight is obtained by multiplying the actual weight by the factor for the age of the calf on the day it was weighted. Although the range from 0 to 155 days is large and would thus tend to decrease the accuracy, the straightness of the curve in this range appears to offset most of the errors.

The factors for correcting to 190 days are contained in Table II. These factors were calculated in the same manner as those from 0 to 155 days, using the intercept of \(-287\) days. These factors were usefully accurate when checked.

The factors developed by the quadratic method are contained in Table III. When tested these factors were not quite as accurate as those calculated by the linear regression method. Table IV contains the accuracy tests of the two methods, and the mean deviations and their standard errors for the random sample of 70 animals tested. The mean deviation for the linear regression was \(-4.15\) pounds with a standard error of \(1.25\) pounds. This deviation amounts to only slightly more than one per cent of the average weaning weight of 380 pounds. The mean deviation for the quadratic method was \(11.01\) pounds with a standard error of \(1.33\) pounds. This deviation represents only three per cent of the average weaning weight, and the factors could, therefore, be used. The factors developed by the quadratic method are accurate enough for most cases, but the
Factors calculated by linear regression are recommended because of their smaller mean deviation in the random sample tested.
**TABLE I**

CORRECTION FACTORS FOR ADJUSTING WEIGHTS OF RANGE CALVES TO A STANDARD AGE OF 155 DAYS  
(Calculated by Linear Regression)

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### TABLE II

**CORRECTION FACTORS FOR ADJUSTING WEIGHTS OF RANGE CALVES TO A STANDARD AGE OF 190 DAYS**

*(Calculated by Linear Regression)*

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CORRECTION FACTORS FOR ADJUSTING WEIGHTS OF RANGE CALVES TO A STANDARD AGE OF 190 DAYS
(Calculated by Quadratic Method)

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Accuracy Test of Correction Factors Developed by Linear Regression and the Quadratic Method.

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*Mean Deviation and standard errors included for the random sample of 70 animals tested.*
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Total deviation = -332
Total deviation = +332

n = 80
n = 80

Mean deviation = -4.15 ± 1.25
Mean deviation = 11.01 ± 1.33
DISCUSSION AND CONCLUSIONS

The growth curve in this article was calculated on the basis of monthly weights taken on 297 calves over a seven year period. Some workers have criticized this method and have advocated using the individual curve rather than the average. (Brody 1945). However, for purposes of developing a correction factor the average is both practical and reasonably accurate. Each time a calf’s weight is corrected it is actually estimating what he will weigh if he grows as the average calf does. It is for this reason that we must know the performance of the average calf.

In spite of the slight departure from a straight line of the growth curve between 155 and 225 days, the linear method is considered accurate enough for all practical purposes due to the small range and small amount of curvature. Tests of a random sample of 70 animals show the mean deviation to be -4.15 or slightly over one per cent error.

Caution should be used in applying these factors to calves raised under different feeding and management practices from those to which the calves used in this paper were subjected. Two factors which might affect the accuracy would be the length of time the calves were left with their dams on the range and whether or not the calves have been creep fed while on the range. Variations in these practices could cause variations in the growth curve, and might be sufficient to introduce considerable error. These factors could probably be used on most of the calves in South Dakota that are raised on the range and are not creep fed.

The factors developed in this study should be helpful in experimental
work for use in selecting calves for bull testing, progeny testing, and feeding trials, and also, in estimating productivity of cows. The purebred breeder could use them to determine which animals should be used heavily in building his breeding herd.

Correction factors for beef cattle should prove even more useful than similar factors have proven for hogs. Due to the longer developmental period in beef cattle previous to breeding, the younger animals will have sufficient time to mature and enter the breeding herd, whereas in hogs, very young gilts can seldom be used regardless of their rapid growth rate.
SUMMARY

Data on 297 calves raised at the Cottonwood Range Field Station from 1942 through 1948 were used in calculating a growth curve and three correction factors. The growth curve was used to determine the ranges that would give the best results in calculating correction factors. The first set of correction factors covered ages from birth to 155 days, with the standard age of 155 days. The second set covered the range from 155 to 225 days with the standard age of 190 days. These two sets of factors were computed using a within calf linear regression. By using these two sets of factors a young calf's weight can be adjusted to 155 days of age and then on to 190. This will probably seldom be necessary as the majority of the calves fall within the 155-225 day limit at weaning time. Both of these factors were usefully accurate when checked.

The third set of factors was calculated by a quadratic method used by Lush and Kincaid (1943). These factors were accurate enough for most uses when tested. However, they were not quite as accurate as those calculated by linear regression and the latter are recommended for use.

The three sets of factors may be used to adjust weights of calves raised under feeding and management practices similar to those which these experimental calves were subjected.
LITERATURE CITED


ACKNOWLEDGEMENT

The writer wishes to express his sincere appreciation to Dr. L. E. Johnson, Head of the Animal Husbandry Department, for helpful suggestions and criticisms during the investigation of the problem and the preparation of this manuscript.

Grateful acknowledgement is also made to Dr. William E. Dinusson and other members of the Animal Husbandry staff for suggestions and criticisms.