May 12, 1951.

To the Graduate Council:

I am submitting to you a thesis written by Will T. Butts, Jr. entitled "Correction Factors for Adjusting Weaning Weights of Beef Calves to a Standard Age". 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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CORRECTION FACTORS FOR ADJUSTING WEANING WEIGHTS OF BEEF CALVES TO A STANDARD AGE

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by
Will T. Butts, Jr.

June, 1951

ACKNOWLEDGEMENT

The writer wishes to express his sincere appreciation to Doctor Harold J. Smith for his valuable assistance in the investigation of the problem and the preparation of this thesis.

To Doctor Everett J. Warwick for his assistance in setting up the statistical procedures used in this work.

To Doctor Bonard S. Wilson for his suggestions in the writing of this thesis.

To Doctor Charles S. Hobbs for his kind aid and assistance in the investigation of this problem.

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INTRODUCTION

In connection with regional cooperative beef cattle breeding projects, it is often desirable to adjust weaning weights of calves to a constant age and sex basis so that data from different breeding groups, different locations within and between states, and different sire groups may be placed on a comparable basis. The practical difficulties involved in weighing all calves at a constant age have caused most workers to develop some system of adjusting weights whereby they could weigh the whole group on a certain day or a series of days and from this data arrive at comparative weights. In general, these methods have adjusted weights within an allowable error for practical work. However, in the case of beef calves, no one method has proved sufficiently flexible to permit its use on animals from different locations and raised under different systems of management.

The cow herds used in experimental work by the University of Tennessee are located on Agricultural Experiment Substations in different sections of the State. Differences in the breeding of these cow herds together with differences in management practices, soils and climate at the various locations afford an excellent opportunity to study the effects of these variables on the development of correction factors applicable to a wide range of conditions. This situation emphasizes the need for a means of placing weaning weights of experimental calves on a comparable basis.

Observation of calf data indicates that, although a particular method of adjustment may correct the mean weight of a group of calves to

a given age with little error, the adjusted weight of the individual calves in the group may show a marked deviation from their actual weight at that age. Even though the mean deviation of the adjusted weight from the actual weight at a given age is small, the mean absolute deviation may be quite large. This condition is becoming increasingly more important as more experimental data is subjected to statistical analysis.

The purpose of this work is to develop correction factors for adjusting weaning weights of calves to a constant age and sex basis. Development of a method of adjusting weaning weights to a standard age should greatly enhance the value of calf weights in experimental work.

REVIEW OF LITERATURE

Bywaters and Willham (1935) developed a method for estimating the rate of growth of pigs approaching market age. Based on a regression line fitted to that segment of the growth curve from the nineteenth to the twenty-fifth week and extended to the age axis, the average age intercept of three sets of data was 65 days. To estimate the rate of growth of a pig, his weight was divided by his age minus 65 days. This system of estimating rate of growth adjusts for differences in age but does not allow for differences in feeding and management.

Following the work of Bywaters and Willham, a method of adjusting weaning weights of pigs was developed by Whatley and Quaife (1937). Using weaning weights on 275 litters on 34 farms during 1936 and 1937, Whatley and Quaife found that the intrafarm regression coefficient was 0.72 pounds per day, the mean weight 30.8 pounds and the mean age 58 days. The authors found an average age intercept of 15 days for that part of the growth curve around 56 days of age. This age intercept was used in the formula:

$$56 \text{ day adjusted weight} = \text{Weight} \times \frac{56 - 15}{\text{Age} - 15}$$

to adjust the pig weights to a standard age. This intercept was not intended to apply to pigs deviating very far from 56 days of age. Errors due to differences in feeding and management were reduced, however, since the regression was calculated on an intrafarm basis.

Phillips and Brier (1940) compared two systems of adjusting weaning weights of lambs to a constant age of 20 weeks. The first system assumed the growth curve of the lambs to be a straight line from birth to weaning. Using this method, 140 days was multiplied by the average daily gain of the lamb from birth to weaning and added to the birth weight to obtain an estimate of the lamb weight at 20 weeks of age. The second method fitted a regression line to that part of the growth curve around 20 weeks of age and plotted an age intercept. Multiplying the lamb's actual weight by the factor $\frac{\text{20 weeks} - \text{age intercept}}{\text{Actual age} - \text{age intercept}}$ gave the 20 week adjusted weight. Use of the age intercept method was more accurate than the average daily gain method.

Koger and Knox (1945) developed a method of adjusting weaning weights of range calves to a constant age. They analyzed weaning weights of calves dropped over an 8 year period and found that the average regression of weight on age within subgroups was 1.33 pounds per day. Observation of their data showed a positive correlation between the weaning weight of a group of calves and the age on weight regression based on the same group of calves. This led them to calculate a variable regression upon which to base their adjustments rather than the use of an average age intercept. Advantages claimed for this system of adjustment are: (1) the form equation $W = w + d\,b$, where W is the corrected weight, w is the actual weight, d is the standard age minus the actual age and b the regression coefficient, is true whether or not the lines of regression have a common point; (2) the variable regression provides a mathematical expression of the relationship of

regression and weight at any given age if such exists; and (3) calculation of estimated weight is simplified by converting the estimating equation to graphic form.

The equation and chart derived by Koger and Knox are not considered suitable for correcting weights where conditions and management are not similiar to those encountered by them.

Dinkel (1949) studied the growth curve of 297 calves dropped over a six year period and developed three sets of correction factors. The first set of correction factors covered ages from birth to 155 days, with a standard age of 155 days. The second set of factors covered the period from 155 days to 225 days of age, with a standard age of 190 days. These two sets of correction factors were based on a within group linear regression. Both factors proved usefully accurate. A third set calculated by a quadratic method developed by Lush and Kincaid (1943) failed to give the accuracy of those methods based on linear regression and was not recommended.

Lush and Kincaid (1943) developed correction factors for adjusting the weights of pigs to a standard age of 154 days. They found that from approximately 100 days of age to 200 days the rate of gain of the pigs was steadily increasing. This increase proved to be relatively constant, thus making it possible to express the increase in rate of gain as a quadratic equation. This expression was used and, from it, correction factors were developed for adjusting weights to 154 days. The authors stated that adjustments of weights of pigs under 135 days of age or over 175 days should be avoided, since the fit of the equation to the growth curve was closer between these ages than at

points beyond. They also suggested that increased accuracy could be obtained by using the average of two 154 day adjusted weights rather than one. This method differs basically from the linear method in that it assumes a constant increase in rate of gain over a stated period, while the linear regression assumes a constant rate of gain.

MATERIAL AND METHODS

Source of Data

The data used in this investigation were periodic weights taken from birth to weaning on 237 calves from cow herds at two locations.

Calves from the cow herd maintained at the Tobacco Experiment Station, Greeneville, represent the 1948 - 1950 calf crops inclusively. One hundred and nineteen calves were produced from this herd. The Greeneville herd was established from grade Hereford heifers bought at the Ewing, Virginia, calf sale in the fall of 1945. These heifers were developed on the station and bred as two-year olds.

Experiments to determine the effects of crossbreeding and time of calving were conducted with this herd during the years covered by this data. These experiments were initiated in 1947 by dividing the herd into four groups on the basis of weight and grade. One of these groups was bred to a registered Hereford bull to calve during January and February. Another group was bred to a registered Angus bull to calve during January and February. For convenience these crossbred Hereford-Angus calves were called Angus calves. The third and fourth groups were bred to calve during March and April, one group being bred to a Hereford bull and the other group to an Angus. The bulls were switched each year within the two calving seasons. The group of cows producing early Hereford calves in 1948 produced early Angus calves in 1949 and early Herefords again in 1950.

The entire Greeneville herd was run on pasture and received corn silage and hay during the winter. The two subgroups calving during January and February received approximately 380 pounds of grain during the winter in addition to roughage. The calves were not creep-fed.

Calf weights were taken at 28 day intervals from birth to weaning. Weights were taken to the nearest five pounds. All calves were weaned on November of each year. A single first day weaning weight was used throughout this investigation, rather than a two or three day average weaning weight. The early calves averaged 287 days of age and the late calves 230 days of age at weaning. The average birth dates were January 17 and March 15 for the respective calving seasons.

Calf weights on 118 calves from the Plateau Experiment Station, Crossville, were analyzed. These calves represent the 1947 - 1950 calf crops inclusively. The crossville cow herd was established from heifers out of native cows and sired by purebred Shorthorn and Hereford bulls. This herd was bred to calve during April and May. The average calving date was April 30. These calves averaged 184 days of age when weaned November 1.

This herd was used in an experiment on the effect of high phosphate fertilization for pastures in a phosphorus deficient area. The herd was divided into three lots. Lots 1 and 2 were grazed on pastures receiving low rates of phosphate fertilization and lot 3 was grazed on pastures receiving high rates of fertilization. There was no significant difference in average daily gain between the different lots of calves. Lots 1 and 2 were handled together.

The cows ran on pasture the entire year, but were housed at night and fed a limited amount of hay during the winter months. Monthly weights from birth to weaning were obtained on the Crossville calves. A single first day weaning weight was used in calculations based on these calves. None of the calves were creep-fed.

Analysis of Data

Growth curves from birth to weaning of various groupings of calves at each location were constructed (Figures 1-11). These were calculated by averaging the ages and weights of calves in the particular groups at each weighing from birth to weaning.

Greeneville calves were grouped within year on the basis of sex, breed, and time of calving. Eight subgroups were studied each year. Crossville calves were grouped each year on the basis of sex and treatment for a total of four subgroups each year. These groups or various combinations thereof were used in all calculations in this study.

Realizing that slight changes in rate of growth might remain undetected by a general inspection of the growth curve, within lot regression coefficients for various combinations of different items (Table II) were calculated for the two locations.

Inspection of the data suggested various methods of adjusting weights of calves to a standard age and sex basis. These methods were calculated and tested. The test group was a 24 calf sample from each location. These calves were selected at random within subgroups.

A standard age of 210 days was selected at Greeneville and 180 days at Crossville.

I. Methods of adjusting weights of beef calves to a standard age.

A. Prorating gain between 28 day weights bracketing standard age.

This method is based on the assumption that the segment of the growth curve between the two periodic weights bracketing the standard age is a straight line. Assume that a Greeneville calf is 200 days of age and weighs 430 pounds on a particular weigh day, and that it weighs 472 pounds on the following weigh day. This calf has gained at the rate of 1.5 pounds per day during the period bracketing the standard age of 210 days. Hence, its adjusted weaning weight would be 445 pounds.

This method was believed to give a close approximation of the actual weight of the calf at the standard age. This adjusted weight was used as a standard for comparing others.

B. Average daily gain from birth to weaning - adjusted from weaning age.

The average daily gain from birth to weaning was calculated for individual calves. This method was included in this study since much of the calf data in the past has been based on this type of adjustment.

C. Within lot weaning age on weight regression coefficient - adjusted from weaning age.

The form equation used in this method of adjusting weaning weights to a standard age was $W = w + d\,b$ where W is the adjusted weight, w is the weight at weaning, d is the standard age minus the age at weaning, and b is the regression coefficient (Koger and Knox 1945).

D. Variable regression coefficient adjusted from weaning age.

Observation that the regression coefficient was positively correlated with average weight of group from which the coefficient was calculated made it desirable to calculate a variable regression for testing against other methods (Tables VIII and XVII). The method used in combining lots in the calculation of the variable regression was similar to that used by Koger and Knox (1945).

Subgroups of each sex at Greeneville were combined for three separate years, two different calving seasons, and sires from two breeds. Subgroups of each sex at Crossville were combined for four separate years and two different lots. Average within lot linear regression coefficients were calculated for each combination of subgroups (Snedecor 1946). These regression coefficients were based on the last five period weights at Greeneville and the last four weights at Crossville. The distribution of calves, as to age at the two locations determined the number of weighings to include in calculating the regression coefficients. Each group's average age and weight during that period upon which the regression coefficient was based was adjusted to the standard age by its own average

regression coefficient (Tables VII and XVI). The relationship of average weight of group at the standard age and regression coefficient formed the basis for a variable regression method of adjusting calf weights to a standard age. This relationship was expressed in graphic form (Davis 1943) for convenience (Figures 12 and 13).

E. Variable regression coefficient - adjusted from nearest weigh date.

This is a variation of method D wherein the calf's weight on the weigh day nearest the standard age is used rather than the actual weaning weight. Weights were adjusted a maximum of 14 days at Greeneville and 15 days at Crossville by this method.

F. Individual lot regression coefficients adjusted from weaning age.

Linear regression coefficients were calculated for eight lots or subgroups at Greeneville and four subgroups at Crossville each year (Tables III - V and XI and XIV). These regression coefficients were based on the last five periodic weights at Greeneville and the last four at Crossville (Snedecor 1946).

The form equation $W = w + d\ b$ was used in making adjustments by this method (Koger and Knox 1945). The November 1 weaning weights of the individual calves were adjusted by the regression coefficients of the subgroups to which the calves belonged.

G. Individual lot regression coefficient - adjusted from the nearest weigh date.

This method is basically the same as method F. The calf's weight on the weigh day nearest the standard age was used rather than the actual weaning weight.

H. Overall within lot regression coefficient - adjusted from weaning age.

An overall average within lot regression coefficient was calculated for each location (Tables VI and XV). These within lot regression coefficients involved 24 groups (95 degrees of freedom within subgroups) at Greeneville and 16 groups (102 degrees of freedom within subgroups) at Crossville. The same periodic weights were used in the calculation of these regression coefficients as were used in method F. The form equation $W = w + d\ b$ was used in adjusting weights by this method.

I. Overall within lot regression coefficients - adjusted from the nearest weigh date.

The same regression coefficients used in method H were used in this method.

II. Method of adjusting weaning weights of heifer calves to a steer basis.

The average birth weights of all heifers and all steers were determined for separate years within locations. The average birth weight of the steers was expressed as a percentage of the average birth weight of the heifers. Average age and average weight of heifers and steers was determined by years at each location for each of the last five weighings

at Greeneville and the last four weighings at Crossville. In each instance, average weight of steers and average weight of heifers was adjusted to the average age of the two groups. The weight of the steers was expressed as a percentage of the weight of the heifers in each case. Overall average percentage factors were calculated at each location. These factors were weighted by years and averaged to obtain an overall sex correction factor (Table X).

RESULTS AND DISCUSSION

Inspection of the growth curves (Figures 1 through 11) showed that the calves studied grew in a relatively straight line from birth to weaning. However, there was considerable variation between years in the rate of growth of calves during late summer and early fall. Preliminary analysis showed a tendency for older calves to gain more slowly than younger calves (Tables I and II). Based on results from the time of calving study at Greeneville, this decrease in rate of gain of calves as age increased was a function of age rather than date of birth.

Methods of adjustment of weaning weights involving average daily gain (Method B) underestimated the weight of the calves at the standard age (Table XIX). Standard ages of 210 days at Greeneville and 180 days of age at Crossville were selected as the most suitable ages of comparison. These standard ages enabled adjustments to be made within the scope of the data. Since both standard ages are below the average weaning ages of all groups, weaning weight adjustments were made to a younger age. Method B failed to take into account the slope and character of that segment of the growth curve over which the adjustments were made. No bias was introduced in adjusting the weaning weights of the early calving groups at Greeneville by this method. The same error of adjustment was present in the average corrected weight of each group. The more common situation in experimental work, however, is the comparison of several groups of dissimilar ages. The time of calving investigation at Greeneville is a case in point. Calves from the early group averaged two months older at weaning than calves from the late group.

The error encountered in the average daily gain method of adjustment was greater in the case of the older calves and bias was introduced into the interpretation of the results. The magnitude of non-random errors was proportionate to the distance the weaning weights were adjusted. General trends in the growth curves of these calves are substantiated by the work of Koger and Knox (1945) and Dinkel (1949).

With the exception of method B, all methods tested attempted to adjust weights on the basis of that part of the growth curve over which the adjustments were made. Regression coefficients based on weaning age and weight (Koger and Knox 1945) and regression coefficients based on a series of weights during the period bracketing the standard age (Dinkel 1949) have been used to estimate rate of gain during this period in the life of calves. Methods C, D. F and H were used to test the accuracy of these two basic methods when the adjustment was based on the actual weaning weight. The error found in the average daily gain method of adjustment caused by differences in age of the calves suggested the testing of regression coefficient principles, applied to periodic weights taken near the standard age. Methods E, G and I tested different regression coefficients applied to individual calf weights taken on the weigh day nearest the standard age.

Adjustments made on the basis of a within lot weaning age on weight regression (Method C) showed too much error (Table XIX) to recommend the use of this method. It proved much more accurate at Crossville than at Greeneville. This difference in accuracy of the same method between the two locations was attributed to the length of time

involved in the adjustments and to differences in the shape of the average growth curves during the period over which the corrections were made. Approximately 50 days were involved in the adjustments at Greeneville and 15 days at Crossville. Decrease in rate of growth of the Greeneville calves, as a group, occurred over a longer period of time than did the decrease in rate of growth of the Crossville calves. Hence, the slope of the growth curve of the Crossville calves changed more during the month prior to weaning than did the slope of the growth curve of the Greeneville calves. The standard age of the Crossville calves usually fell within this period of rapid change in rate of gain, while the standard age of the Greeneville calves occurred during a period when change in rate of gain was much less rapid. Therefore, weaning age on weight regression coefficients estimated much more accurately the slope of that segment of the growth curves over which adjustments were made at Crossville than at Greeneville.

The variable regression method (D) proved much more accurate than the above method at Greeneville and less accurate at Crossville (Table XIX). It was interesting to note that, although method D showed a mean deviation of - 7 pounds at Greeneville and - 14 pounds at Crossville, the mean absolute deviation at each station was 15.9 pounds.

In an effort to test the closeness of fit of lines of regression based on the variable regression coefficient (Method D), individual lot regression coefficients were applied to weaning weights as a method of adjustment (Method F). Use of this method gave virtually the same results as the variable regression method (Table XIX). This seemed to

indicate that the variable regression (Method D) was accurately estimating the slope of the growth curve of the calves, during that period for which it was calculated.

Weights of the two test groups were adjusted on the basis of an overall within lot regression coefficient (Method H). This method was slightly less accurate than either of the above two methods (Methods D and F). Results from the use of this method indicated the need for estimating the rate of growth of the individual calves rather than merely that of the average calf. It was realized, of course, that any method of adjustment, fundamentally, is based on the average individual.

None of the adjustment methods based on the November 1 weaning weight were deemed satisfactory. In the case of the three linear regression methods (D, F and H), several factors may account for the error found. If the calves were gaining at a decreasing rate at the standard age, the weaning weight would fall below the line of regression. Since the adjustment is made along a line parallel to the line of regression, adjustments of actual weaning weights to a younger standard age would underestimate the weight of the calf at the standard age. Inspection of the data (Table XIX) lends support to this hypothesis. Methods D, F and H underestimated the calves at both locations. Year to year variation of change in rate of gain during the period bracketing the standard age was felt to preclude the possibility of developing a method which would take the magnitude of this change into account.

Linear regression methods which adjusted weights of individual calves taken on the weigh day nearest the standard age proved very

satisfactory (Methods E, G and I). The difference in accuracy between locations found in all methods using the November 1 weight as the base weight was not noted in these methods using the weight on the nearest weigh day as the base weight (Table XIX). The variable regression method (E) was deemed preferable, since it could be expressed in graphic form for rapid corrections (Figures 12 and 13). To use these momographs, lay a straight edge across the age on the left hand scale and observed weight on the right hand scale. Corrected weight is read directly from the center scale.

If further accuracy is desired, three or more periodic weights bracketing the standard age could be averaged and this average weight adjusted to the standard age by means of the variable regression Method (E). This estimate of weight at the standard age would probably be slightly more accurate than that obtained by use of the base method (A). However, prorating gain between 28 day weights bracketing the standard age was felt to be satisfactory. This method took into account the average of two weights and the slope of the growth curve immediately surrounding the standard age.

A sex correction factor was developed (Table X). Study of growth curves suggested that the difference in weight between steer calves and heifer calves was constant from birth to weaning, when expressed as a percentage. More variation was noted between years than within years. This variation was partially explained by the distribution of cows having heifers and steers each year. The average sex correction factor of 1.085 agrees with the sex difference reported by Koger and Knox (1945). To convert the weight of a heifer calf to a steer

basis, multiply the weight of the heifer by 1.085.

SUMMARY

Growth and weaning records of calves at the substations at Greeneville, in East Tennessee, and Crossville, on the Cumberland Plateau, were analyzed and correction factors developed for use at these stations. These methods were based on calf weights taken at 28 day intervals in herds used for other experiments. A total of 119 calves over a three year period were studied at Greeneville and 116 calves over a four year period were studied at Crossville.

Average growth curves of all groups of calves studied approximated a straight line from birth to weaning, however, growth curves of individual calves showed marked deviations from the average line.

A sex difference was found at all ages from birth to weaning at both locations. This difference when expressed as a percentage of the weight of the steers and heifers was not found to vary significantly between birth and weaning or between locations within years. Study of this data led to the calculation of an average percentage factor of 1.085 which can be used to convert heifer calf weights to a steer basis.

A total of eight methods were used to adjust weaning weights to a constant age. Factors used in these methods were calculated from all calves at both locations. To compare these eight methods of adjusting calf weights, a group of 24 calves at each station was selected at random within subgroups and their weights adjusted to a standard age of 210 days at Greeneville and 180 days at Crossville. The mean absolute deviations of the various methods were subjected to statistical analysis. Three of the eight methods tested adjusted the calf weights a maximum of 14 days.

There was no significant difference between these three methods, and all were considered satisfactory. Five of the methods adjusted the weights over a period longer than 14 days. None of these methods were accurate enough to recommend their use.

The data analyzed thus far do not support the idea that a single correction factor can be developed which will apply to calves raised in different environments.

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APPENDIX

TABLE I

COMPARISON OF RATE OF GAIN OF CALVES AT THE DIFFERENT STATIONS

Comparison	Stations	
	Greeneville	Crossville
Av. daily gain from birth to weaning, lbs.*	1.78	2.19
Av. daily gain August 1 to weaning, lbs.*	—	1.97
Av. daily gain July 14 to weaning, lbs.*	1.59	—

*Calves were weaned November 1 at Greeneville and October 31 at Crossville. Average of three years results (119 calves) at Greeneville and four years (116 calves) at Crossville.

TABLE II

WITHIN LOT REGRESSION COEFFICIENTS FOR VARIOUS COMBINATIONS OF DIFFERENT ITEMS*

Items	Stations	
	Greeneville	Crossville
Weaning age - Weaning weight	1.093	1.456
Day in season calved - Av. daily gain from birth to weaning	.0027	.0020
Day in season calved - Av. daily gain from August 1 to weaning	—	.0034
Day in season calved - Av. daily gain from July 14 to weaning	.0008	—
Weight August 1 - Av. daily gain August 1 to weaning	—	.0009
Weight July 14 - Av. daily gain July 14 to weaning	.0028	—
Birth weight - Av. daily gain from birth to weaning	.0085	.0021

*Within lot regressions involves 24 groups (95 degrees of freedom within subgroups) at Greeneville and 16 groups (100 degrees of freedom within subgroups) at Crossville.

TABLE III

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS FOR THE 1948 GREENEVILLE CALVES

Groups	No. Calves	Av. Age*	Av. Weight*	Regression* Coefficient	Age Intercept
Early Angus Steers	6	234.80	460	1.689	- 37.55
Early Angus Heifers	4	221.80	412	1.586	- 37.97
Early Hereford Steers	4	231.30	448	1.711	- 30.54
Early Hereford Heifers	7	234.80	431	1.442	- 64.09
Late Angus Steers	5	170.20	366	1.786	- 34.73
Late Angus Heifers	5	186.00	384	1.614	- 51.92
Late Hereford Steers	7	177.80	384	1.794	- 36.25
Late Hereford Heifers	4	183.80	348	1.478	- 51.65
All Steers	22	201.35	412	1.749	- 34.21
All Heifers	20	209.80	399	1.521	- 52.53
All Early	21	231.66	439	1.591	- 44.27
All Late	21	179.09	373	1.689	- 41.75
All Angus	20	203.85	408	1.674	- 39.88
All Hereford	22	206.75	404	1.609	- 44.34
All Early Steers	10	233.40	455	1.698	- 34.56
All Early Heifers	11	230.07	424	1.494	- 53.73
All Late Steers	12	174.63	377	1.791	- 35.87
All Late Heifers	9	185.02	368	1.554	- 51.79
Total	42	205.37	406	1.640	- 42.19

*Calculated over the last 5 weigh dates.

TABLE IV

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS FOR THE 1949 GREENEVILLE CALVES

Groups	No. Calves	Av. Age*	Av. Weight*	Regression* Coefficient	Age Intercept
Early Angus Steers	3	222.90	444	1.509	- 71.33
Early Angus Heifers	7	228.20	447	1.223	- 137.29
Early Hereford Steers	7	226.80	473	1.509	- 86.65
Early Hereford Heifers	5	225.60	456	1.248	- 139.78
Late Angus Steers	4	171.20	370	1.628	- 56.07
Late Angus Heifers	6	176.20	350	1.473	- 61.41
Late Hereford Steers	7	168.90	402	1.789	- 55.81
Late Hereford Heifers	2	176.70	366	1.445	- 76.59
All Steers	21	196.35	426	1.625	- 65.80
All Heifers	20	206.80	412	1.326	- 103.91
All Early	22	226.44	457	1.359	- 109.84
All Late	19	172.51	375	1.619	- 59.11
All Angus	20	200.40	402	1.422	- 82.30
All Hereford	21	202.44	435	1.534	- 81.13
All Early Steers	10	225.63	464	1.509	- 81.76
All Early Heifers	12	227.12	451	1.233	- 138.65
All Late Steers	11	169.73	390	1.730	- 55.70
All Late Heifers	8	176.32	354	1.466	- 65.15
Total	41	201.45	419	1.479	- 81.85

*Calculated over the last 5 weigh dates.

TABLE V

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS FOR THE 1950 GREENEVILLE CALVES

Groups	No. Calves	Av. Age*	Av. Weight*	Regression* Coefficient	Age Intercept
Early Angus Steers	1	232.80	575	1.920	- 66.68
Early Angus Heifers	8	233.80	444	1.491	- 63.99
Early Hereford Steers	6	228.50	492	1.769	- 49.62
Early Hereford Heifers	2	234.80	451	1.409	- 85.29
Late Angus Steers	7	165.50	412	1.883	- 53.30
Late Angus Heifers	7	169.70	360	1.647	- 48.88
Late Hereford Steers	3	174.10	420	1.822	- 56.42
Late Hereford Heifers	2	171.30	314	1.448	- 43.55
All Steers	17	193.21	451	1.834	- 52.70
All Heifers	19	203.71	400	1.535	- 56.88
All Early	17	231.99	469	1.604	- 60.40
All Late	19	169.02	384	1.741	- 51.54
All Angus	23	193.46	415	1.676	- 54.15
All Hereford	13	208.12	442	1.676	- 55.60
All Early Steers	7	229.11	504	1.790	- 52.45
All Early Heifers	10	234.00	445	1.474	- 67.90
All Late Steers	10	168.08	414	1.864	- 54.02
All Late Heifers	9	170.06	350	1.603	- 48.28
Total	36	198.75	424	1.676	- 54.23

*Calculated over the last 5 weigh dates.

TABLE VI

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS FOR THE 1948 - 1949 - 1950 GREENEVILLE CALVES

Groups	No. Calves	Av. Age*	Av. Weight*	Regression* Coefficient	Age Intercept
Early Angus Steers	10	231.03	467	1.659	- 50.46
Early Angus Heifers	19	229.21	438	1.412	- 80.99
Early Hereford Steers	17	228.46	474	1.649	- 58.99
Early Hereford Heifers	14	231.51	443	1.367	- 92.56
Late Angus Steers	16	168.39	387	1.789	- 47.93
Late Angus Heifers	18	176.39	363	1.580	- 53.36
Late Hereford Steers	17	173.48	398	1.797	- 48.00
Late Hereford Heifers	8	178.90	344	1.462	- 56.39
All Steers	60	197.29	428	1.730	- 50.11
All Heifers	59	206.82	404	1.460	- 69.86
All Early	60	229.84	454	1.510	- 70.82
All Late	59	173.73	377	1.683	- 50.27
All Angus	63	198.96	408	1.595	- 56.84
All Hereford	56	205.45	424	1.597	- 60.05
All Early Steers	27	229.41	471	1.652	- 55.70
All Early Heifers	33	230.19	440	1.393	- 85.68
All Late Steers	33	171.02	393	1.793	- 48.17
All Late Heifers	26	177.17	357	1.544	- 54.05
Total	119	202.02	416	1.596	- 58.60

*Calculated over the last 5 weigh dates.

TABLE VII

RELATIONSHIP OF AVERAGE WEIGHT OF GROUP AT 210 DAYS AGE AND REGRESSION COEFFICIENT AT GREENEVILLE

Group	Adjusted Weight (X)	Regression Coefficient (Y)
1948 Steers	428	1.749
Heifers	399	1.521
1949 Steers	449	1.625
Heifers	416	1.326
1950 Steers	482	1.834
Heifers	409	1.535
Early Steers	440	1.652
Heifers	412	1.393
Late Steers	463	1.793
Heifers	408	1.544
Angus Steers	449	1.739
Heifers	412	1.494
Hereford Steers	453	1.723
Heifers	403	1.402

TABLE VIII

ANALYSIS OF DATA IN TABLE VII

Degrees of Freedom	Sums of Squares and Products			Regression Coefficient	Correlation Coefficient
	Sx^2	Sxy	Sy^2		
13	8,606	44.59	0.3337	0.0052	.83*

*Significant at the 1 per cent level.

TABLE IX

WEIGHTS OF GREENEVILLE CALVES ADJUSTED TO A STANDARD AGE BY VARIOUS METHODS

Calf No.	Birth Weight	Age Weaned	Weight at Weaning	A	B	A-B	C	A-C	D	A-D	E	A-E	F	A-F	G	A-G	H	A-H	I	A-I
7-8	69	266	520	422	425	3	464	42	430	8	424	2	425	3	423	1	431	9	423	1
27-8	77	282	545	407	426	19	474	67	430	23	395	12	422	15	399	8	430	23	398	9
24-8	66	229	490	445	455	10	471	26	456	11	449	4	456	11	439	6	460	15	438	7
46-8	52	240	425	372	378	6	395	23	385	13	371	1	371	1	370	2	377	5	370	2
25-9	64	304	520	406	379	27	427	21	389	17	408	2	378	28	408	2	370	36	407	1
12-9	80	284	565	456	439	17	492	36	441	15	456	0	453	3	454	2	447	9	454	2
37-9	65	229	475	458	441	17	456	2	443	15	466	8	444	14	465	7	445	13	464	6
17-9	92	227	575	554	539	15	558	4	537	17	566	12	545	9	560	6	548	6	558	4
6-0	75	289	665	544	504	40	587	43	506	38	546	2	513	31	547	3	539	5	545	1
26-0	88	278	580	470	460	10	512	42	460	10	478	8	460	10	479	9	471	1	481	11
16-0	66	234	590	552	536	16	566	14	537	15	554	2	545	7	553	1	552	0	551	1
46-0	68	232	570	519	522	3	548	29	524	5	518	1	530	11	516	3	535	16	515	4
3-8	52	285	520	389	397	8	446	57	408	19	386	3	403	14	388	1	400	11	388	1
30-8	56	296	455	375	339	36	370	5	352	23	376	1	331	44	376	1	318	57	375	0
13-8	57	247	450	382	391	9	413	31	397	15	386	4	390	8	384	2	391	9	384	2
40-8	60	239	410	373	368	5	381	8	372	1	372	1	367	6	372	1	364	9	372	1
35-9	70	251	545	495	467	28	504	9	470	25	499	4	495	0	509	14	480	15	504	9
3-9	67	274	450	400	361	39	386	14	368	32	393	7	370	30	395	5	348	52	392	8
43-9	68	232	400	385	369	16	378	7	371	14	388	3	368	17	389	4	365	20	390	5
20-9	78	233	460	420	422	2	437	17	424	4	418	2	427	7	417	3	423	3	418	2
10-0	57	290	520	407	392	15	441	34	402	5	408	1	401	6	407	0	392	15	408	1
30-0	74	286	515	448	398	50	440	8	403	45	450	2	408	40	448	0	394	54	453	5
20-0	50	239	405	359	362	3	376	17	368	9	359	0	357	2	358	1	359	0	358	1
43-0	63	227	380	356	356	0	363	7	359	3	353	3	355	1	356	0	353	3	358	2
Mean				433	422	16.4	454	23.5	426	15.9	434	3.5	426	13.2	434	3.4	425	16.1	434	3.6
Standard deviation of the deviations						13.673		17.609		10.919		3.428		12.431		3.439		16.857		3.189

TABLE X

FACTORS FOR CONVERTING HEIFER CALF WEIGHTS TO A STEER BASIS[1]

Location	Year	Periods						
		Birth	Fourth[2]	Third[2]	Second[2]	First[2]	Weaning	Mean
Greeneville	1948	1.063	1.061	1.058	1.063	1.075	1.094	1.069
	1949	1.111	1.049	1.065	1.067	1.101	1.097	1.079
	1950	1.153	1.181	1.171	1.178	1.175	1.185	1.179
	Combined	1.106	1.090	1.090	1.100	1.110	1.120	1.104
Crossville	1947	1.099		1.115	1.122	1.101	1.106	1.111
	1948	1.075		1.039	1.027	1.035	1.028	1.034
	1949	1.045		1.051	1.065	1.032	1.011	1.038
	1950	1.159		1.135	1.129	1.120	1.153	1.132
	Combined	1.094		1.083	1.078	1.060	1.070	1.070
Combined								1.085[3]

[1]These factors were developed by dividing the mean weight of the steer calves by the mean weight of the heifer calves at various periods from birth to weaning. The mean weights were adjusted to an average age in each case. In no case was there a great difference in the mean age of the two sexes.

[2]These headings refer to the first, second, third, and fourth weigh dates prior to weaning.

[3]This factor is the mean of the combined mean factors at both locations weighted on the basis of the number of years involved at each location.

TABLE XI

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS
FOR THE 1947 CROSSVILLE CALVES

Group	No. Calves	Av. Age	Av. Wt.	Regression	Age Intercept
1 and 2 Steers	9	129.50	394	2.158	- 53.08
1 and 2 Heifers	11	128.50	353	2.136	- 36.76
3 Steers	5	147.50	437	2.188	- 52.23
3 Heifers	5	150.5	403	1.912	- 60.27
All Steers	14	135.93	409	2.169	- 52.64
All Heifers	16	135.38	369	2.066	- 43.23
All 1 and 2	20	128.95	371	2.146	- 43.93
All 3	10	149.00	420	2.050	- 55.88
Total	30	135.63	387	2.114	- 47.44

TABLE XII

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS
FOR THE 1948 CROSSVILLE CALVES

Group	No. Calves	Av. Age	Av. Wt.	Regression	Age Intercept
1 and 2 Steers	13	122.50	364	2.121	- 49.12
1 and 2 Heifers	6	138.50	384	1.931	- 60.36
3 Steers	4	151.50	420	1.788	- 83.40
3 Heifers	6	152.50	421	2.008	- 57.16
All Steers	17	129.32	377	2.042	- 55.30
All Heifers	12	145.50	402	1.969	- 58.66
All 1 and 2	19	127.55	370	2.061	- 51.97
All 3	10	152.10	421	1.920	- 67.17
Total	29	136.02	388	2.012	- 56.82

TABLE XIII

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS FOR
THE 1949 CROSSVILLE CALVES

Group	No. Calves	Av. Age	Av. Wt.	Regression	Age Intercept
1 and 2 Steers	10	138.75	387	1.703	- 88.50
1 and 2 Heifers	9	126.75	347	1.880	- 58.22
3 Steers	4	153.75	460	2.017	- 74.31
3 Heifers	4	173.75	485	2.064	- 61.23
All Steers	14	143.04	408	1.793	- 84.51
All Heifers	13	141.21	389	1.936	- 59.72
All 1 and 2	19	133.07	368	1.787	- 72.86
All 3	8	163.75	472	2.040	- 67.62
Total	27	142.16	399	1.862	- 72.13

TABLE XIV

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS
FOR THE 1950 CROSSVILLE CALVES

Group	No. Calves	Av. Age	Av. Wt.	Regression	Age Intercept
1 and 2 Steers	13	134.75	377	2.015	- 52.35
1 and 2 Heifers	8	141.75	346	1.791	- 51.44
3 Steers	7	148.75	410	1.948	- 61.72
3 Heifers	4	145.75	359	1.839	- 49.46
All Steers	20	139.65	389	1.991	- 55.73
All Heifers	12	143.08	350	1.807	- 50.61
All 1 and 2	21	137.42	365	1.929	- 51.80
All 3	11	147.66	392	1.909	- 57.68
Total	32	140.94	374	1.922	- 53.65

TABLE XV

WITHIN LOT AGE ON WEIGHT LINEAR REGRESSIONS FOR THE
1947 - 48 - 49 - 50 CROSSVILLE CALVES

Group	No. Calves	Av. Age	Av. Wt.	Regression	Age Intercept
1 and 2 Steers	45	131.05	379	2.004	- 58.07
1 and 2 Heifers	34	132.92	355	1.951	- 49.04
3 Steers	20	149.99	429	1.991	- 65.48
3 Heifers	19	155.03	416	1.958	- 57.43
All Steers	65	136.88	394	2.000	- 60.12
All Heifers	53	140.84	377	1.954	- 52.10
All 1 and 2	79	131.85	369	1.981	- 54.42
All 3	39	152.44	423	1.975	- 61.74
Total	118	138.66	387	1.979	- 54.89

TABLE XVI

RELATIONSHIP OF AVERAGE WEIGHT OF GROUP AT 180 DAYS AGE AND REGRESSION COEFFICIENT AT CROSSVILLE

Group	Adjusted Weight (X)	Regression Coefficient (Y)
1947 Steers	504	2.169
Heifers	462	2.066
1948 Steers	481	2.042
Heifers	469	1.969
1949 Steers	474	1.793
Heifers	465	1.936
1950 Steers	469	1.991
Heifers	417	1.807
Lot 1 and 2 Steers	477	2.004
Heifers	447	1.951
Lot 3 Steers	489	1.991
Heifers	465	1.958

TABLE XVII

ANALYSIS OF DATA IN TABLE XVI

Degrees of Freedom	Sums of Squares and Products			Regression Coefficient	Correlation Coefficient
	Sx^2	Sxy	Sy^2		
11	5,120	16.070	0.115485	.0031	.66*

*Significant at the 5 per cent level.

TABLE XVIII

WEIGHTS OF CROSSVILLE CALVES ADJUSTED TO A STANDARD AGE BY VARIOUS METHODS

Calf No.	Birth Weight	Age Weaned	Weight at Weaning	A	B	A-B	C	A-C	D	A-D	E	A-E	F	A-F	G	A-G	H	A-H	I	A-I
481-482	78	209	552	535	486	49	504	31	493	42	537	2	489	46	536	1	495	40	536	1
477-478	74	210	580	534	508	26	534	0	518	16	534	0	515	19	534	0	521	13	534	0
467-468	60	223	528	463	438	25	462	1	446	17	466	3	436	27	462	1	443	20	464	1
472-473	68	185	500	492	488	4	492	0	490	2	490	2	489	3	489	3	490	2	490	2
492-493	65	212	552	539	478	61	503	36	488	51	540	1	482	57	540	1	489	50	540	1
490-491	65	212	500	465	434	31	451	14	440	25	466	1	439	26	466	1	437	28	466	1
442	66	196	534	523	496	27	509	14	501	22	543	20	500	23	542	19	502	21	540	17
411	66	192	500	489	473	16	481	8	477	12	477	12	475	14	475	14	476	13	476	13
403-404	66	210	520	478	455	23	474	4	462	16	478	0	462	16	478	0	461	17	478	0
459	60	191	480	467	456	11	463	4	459	8	459	8	459	8	459	8	458	9	458	9
401-402	74	203	526	482	475	7	490	8	480	2	482	0	485	3	499	17	480	2	482	0
434	64	186	592	575	575	0	583	8	578	3	578	3	580	5	580	5	580	5	580	5
354	64	198	480	474	442	32	452	22	446	28	495	21	449	25	490	16	444	30	494	20
389	52	190	486	483	463	20	471	12	467	16	467	16	469	14	469	14	466	17	466	17
383	50	196	476	435	441	6	451	16	446	11	425	10	446	11	426	9	444	9	428	7
387	70	223	440	424	369	55	374	50	369	55	427	3	359	65	426	2	355	69	424	0
382	88	218	576	511	491	20	517	6	498	13	513	2	499	12	514	3	501	10	514	3
398	68	221	562	501	470	31	499	2	481	20	506	5	477	24	507	6	481	20	508	7
8	90	199	540	496	497	1	511	15	501	5	493	3	502	6	492	4	502	6	492	4
21	61	186	366	355	356	1	357	2	356	1	356	1	354	1	354	1	354	1	354	1
15	68	208	514	460	454	6	471	11	460	0	460	0	464	4	460	0	459	1	460	0
20	67	200	420	387	385	2	389	2	386	1	386	1	384	3	388	1	380	7	390	3
4	90	193	512	490	484	6	492	2	486	4	486	4	487	3	487	3	486	4	486	4
17	65	210	378	344	333	11	332	2	333	11	344	0	323	21	344	0	319	25	344	0
Mean				475	456	19.6	469	11.2	461	15.9	475	4.9	459	18.2	476	5.4	459	17.5	475	4.8
Standard deviation of the deviations						17.328		12.548		15.281		6.318		17.064		6.129		16.694		6.076

TABLE XIX

COMPARISON OF VARIOUS METHODS OF ADJUSTING WEANING WEIGHTS OF BEEF CALVES TO A STANDARD AGE

Method	Stations					
	Greeneville (standard age 210 days			Crossville (standard age 180 days)		
	Average adjusted weight*	Mean absolute deviation	Standard deviation of deviations	Average adjusted weight*	Mean absolute deviation	Standard deviation of deviations
A. Prorating gain between 28 day weights bracketing standard age	433**	-	-	475**	-	-
B. Average daily gain from birth to weaning - adjusted from weaning age	422	16.4	13.7	456	19.6	17.3
C. Within lot weaning age on weight regression - adjusted from weaning age	454	23.5	17.6	469	11.2	12.5
D. Variable regression - adjusted from weaning age***	426	15.9	10.9	461	15.9	15.3
E. Variable regression - adjusted from nearest weigh date ***	434	3.5	3.4	475	4.9	6.3

(continued)

TABLE XIX (continued)

Method	Stations					
	Greeneville (standard age 210 days)			Crossville (standard age 180 days)		
	Average adjusted weight*	Mean absolute deviation	Standard deviation of deviations	Average adjusted weight*	Mean absolute deviation	Standard deviation of deviations
F. Individual lot regression - adjusted from weaning age ***	426	13.2	12.4	459	18.2	17.1
G. Individual lot regression - adjusted from nearest weigh date ***	434	3.4	3.4	476	5.4	6.1
H. Overall within lot regression - adjusted from weaning age ***	425	16.1	16.8	459	17.5	16.7
I. Overall within lot regression - adjusted from nearest weigh date ***	343	3.6	3.2	475	4.8	6.1

* For a group of 24 calves at each station selected at random within subgroups.

** This adjusted weight used as a standard for comparing others.

*** These regressions based on last four (Crossville) or five (Greeneville) weighings.

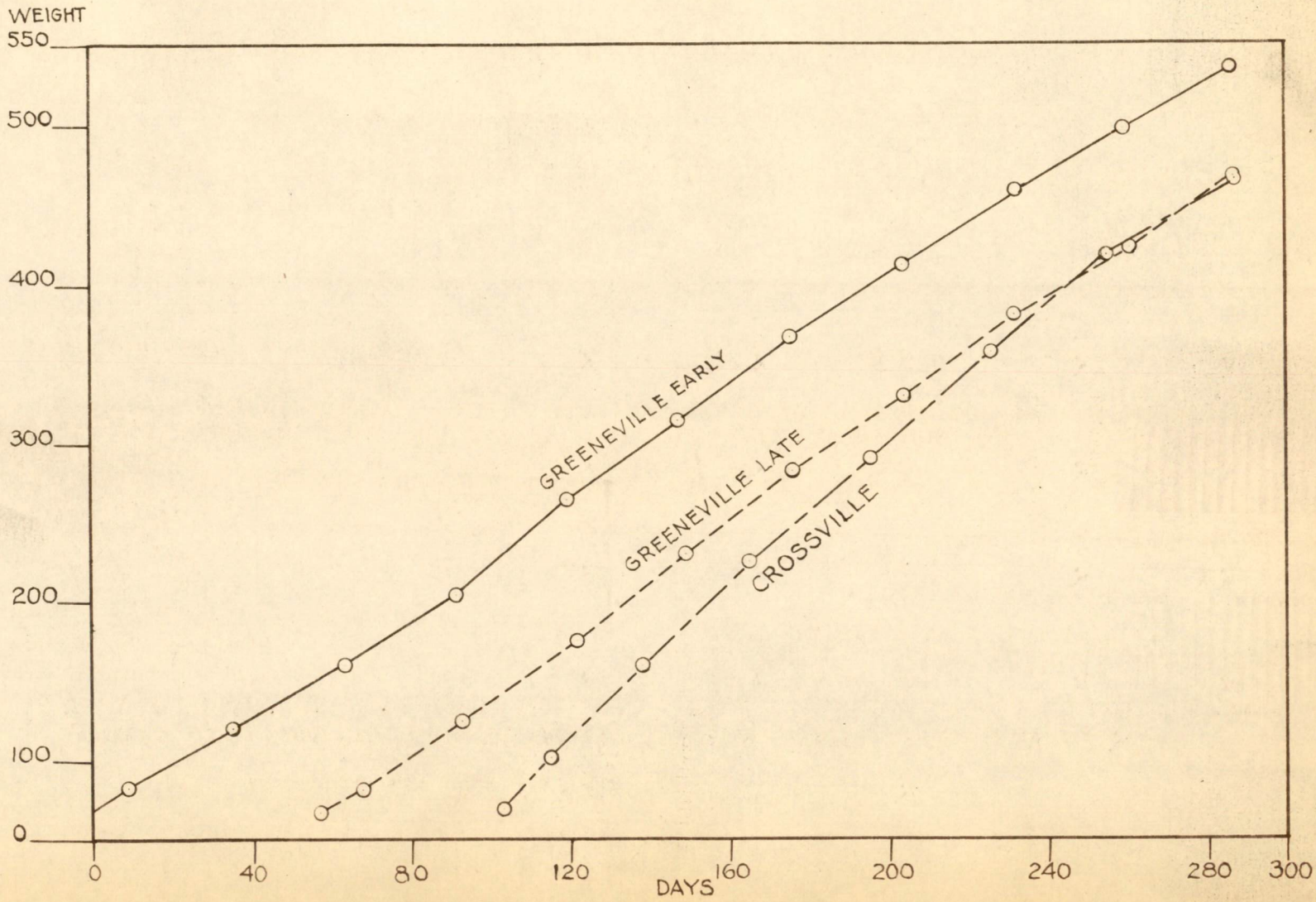

FIG. 1. AVERAGE GROWTH CURVES OF CALVES AT GREENEVILLE AND CROSSVILLE 1948, 49, 50.

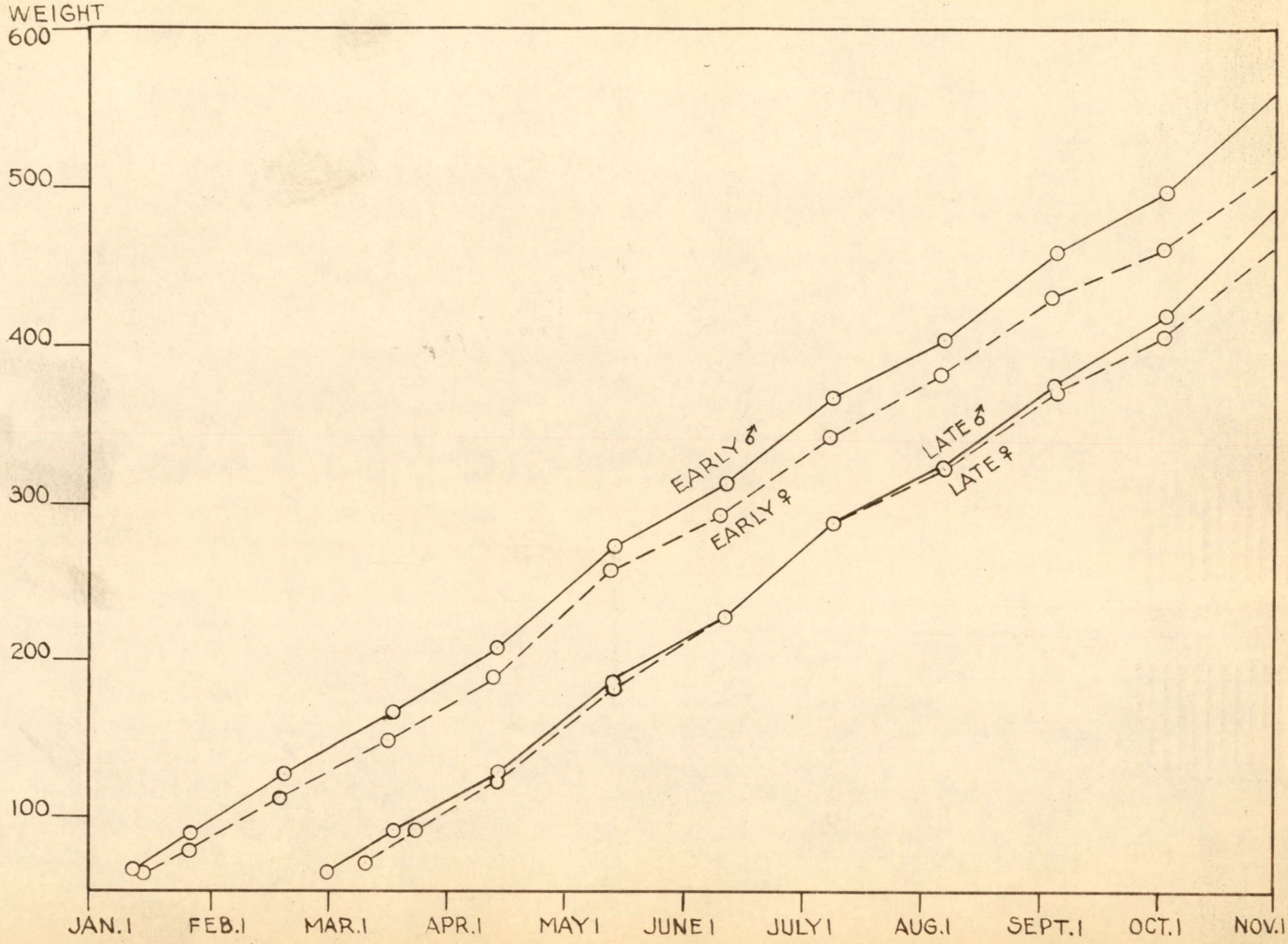

FIG. 2. AVERAGE GROWTH CURVES OF CALVES AT GREENEVILLE 1948.

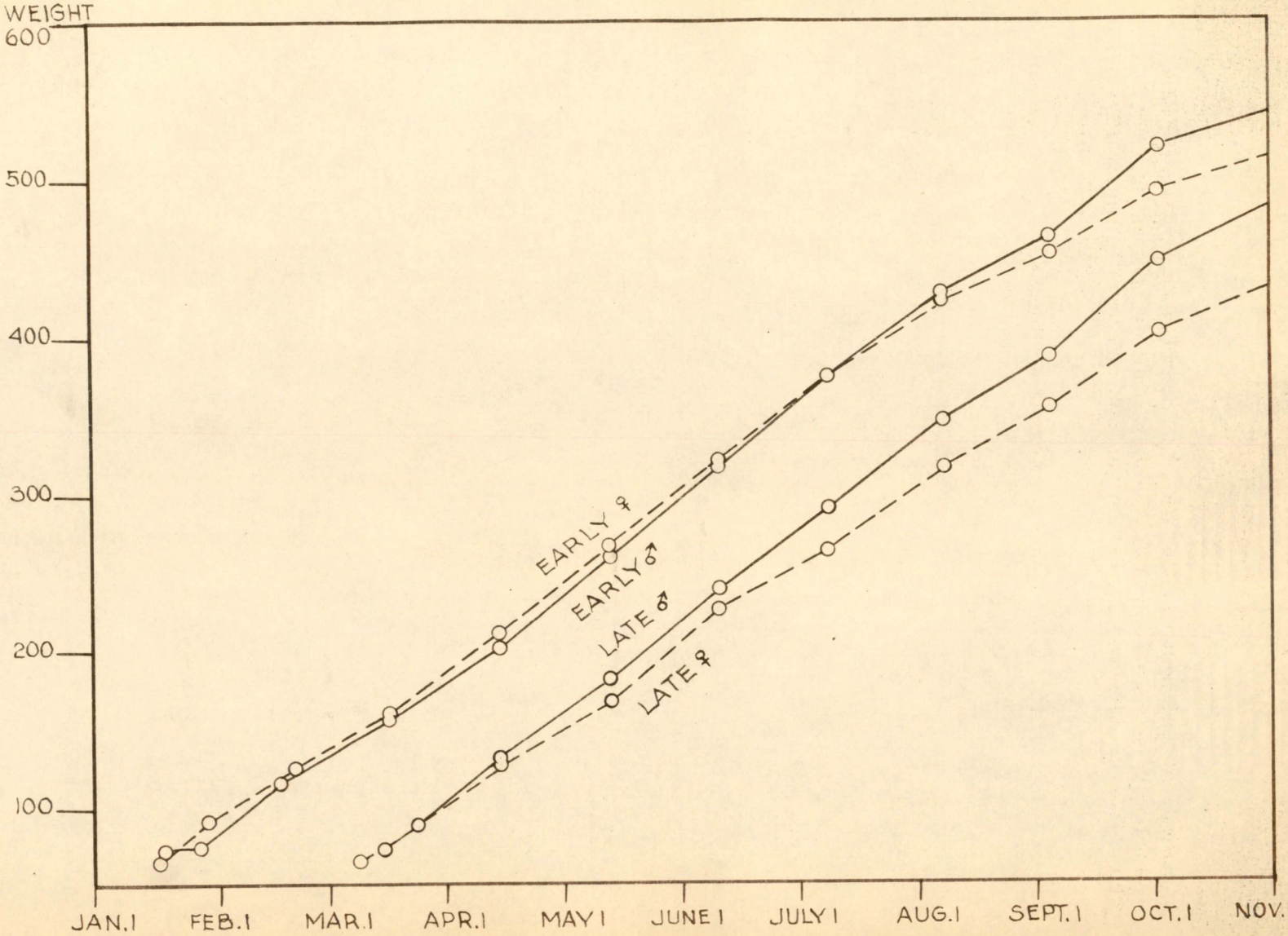

FIG. 3. AVERAGE GROWTH CURVES OF CALVES AT GREENEVILLE 1949

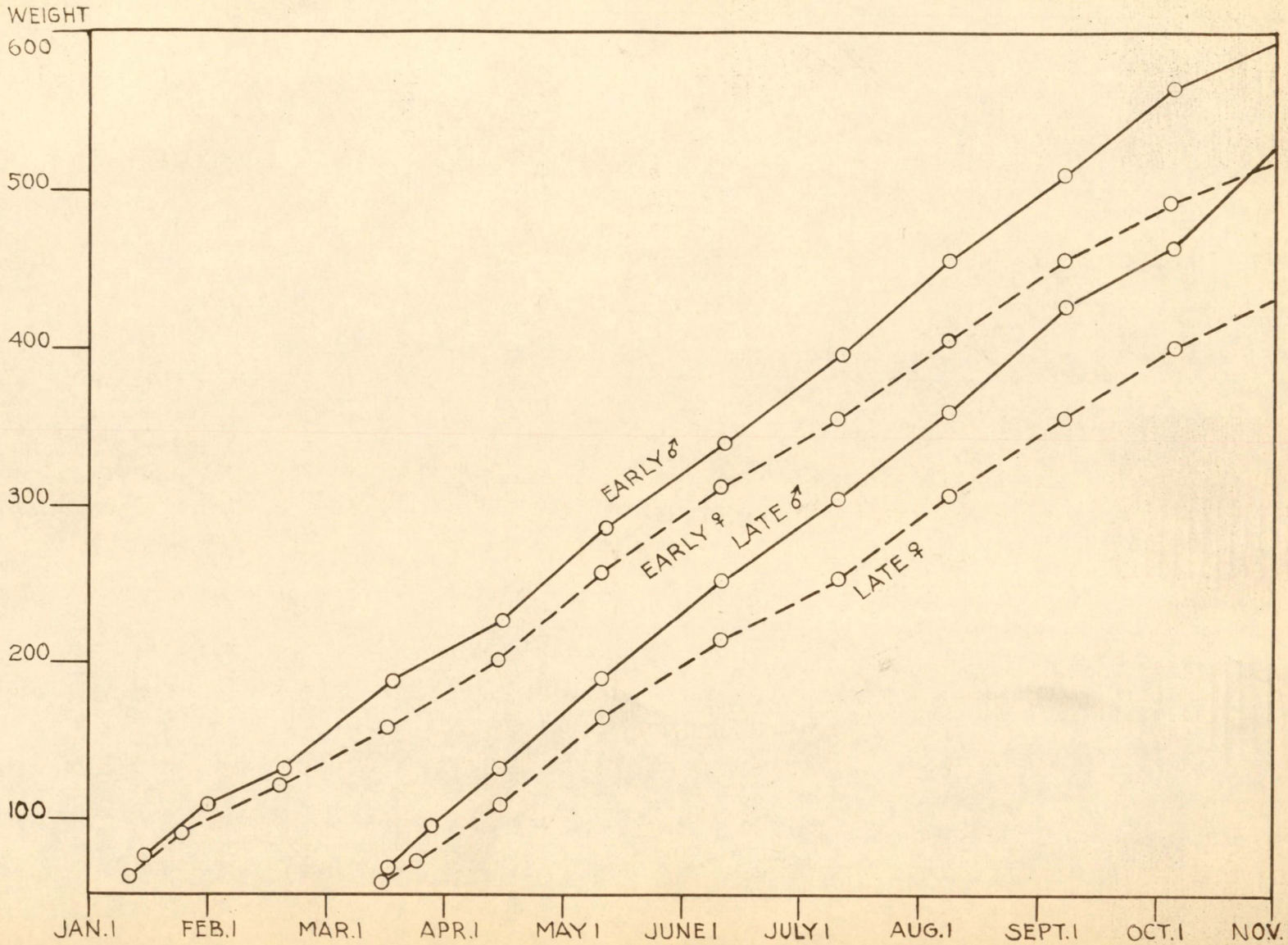

FIG.4 AVERAGE GROWTH CURVES OF CALVES AT GREENEVILLE 1950.

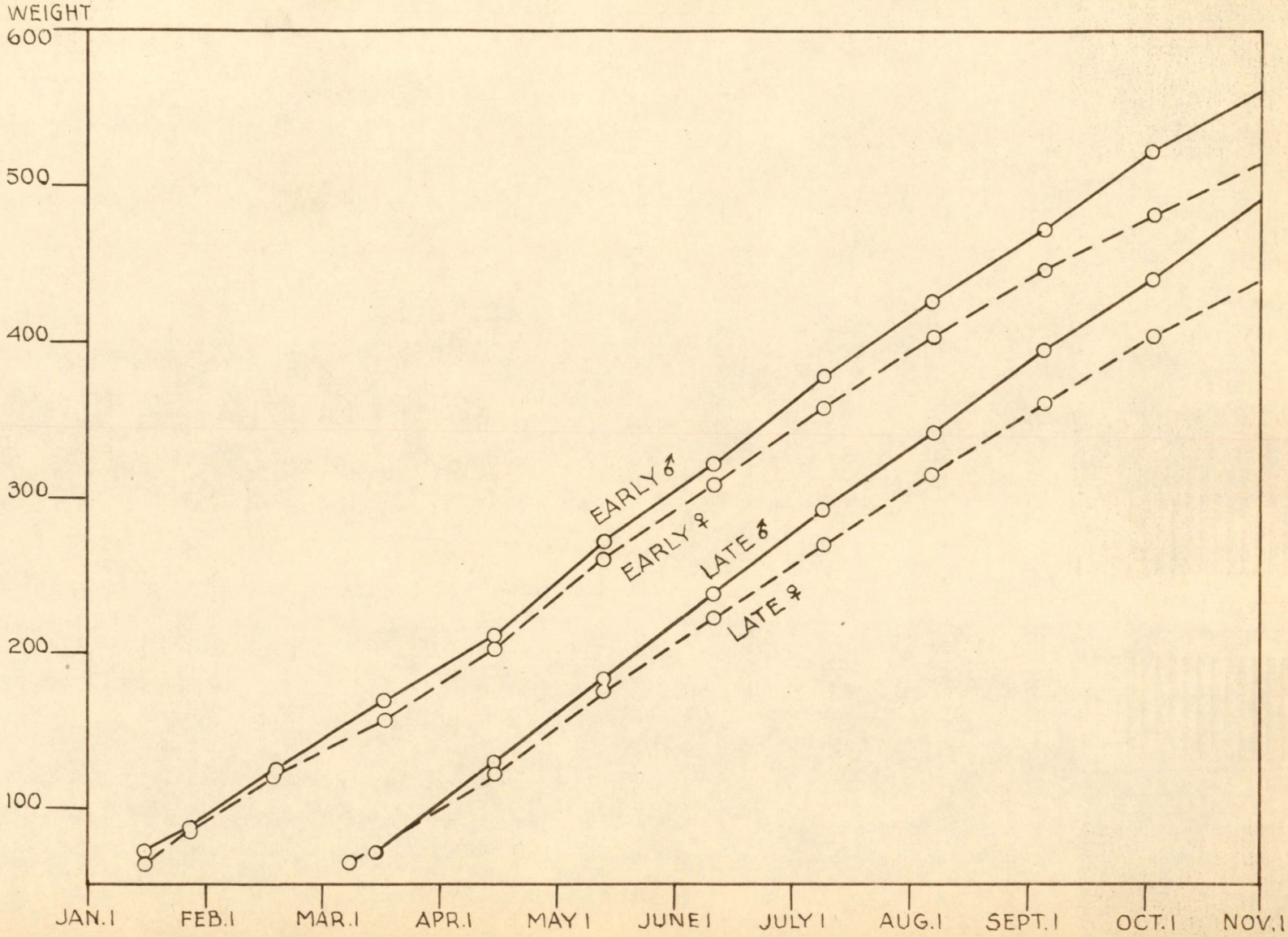

FIG. 5. AVERAGE GROWTH CURVES OF CALVES AT GREENEVILLE 1948, 49, 50.

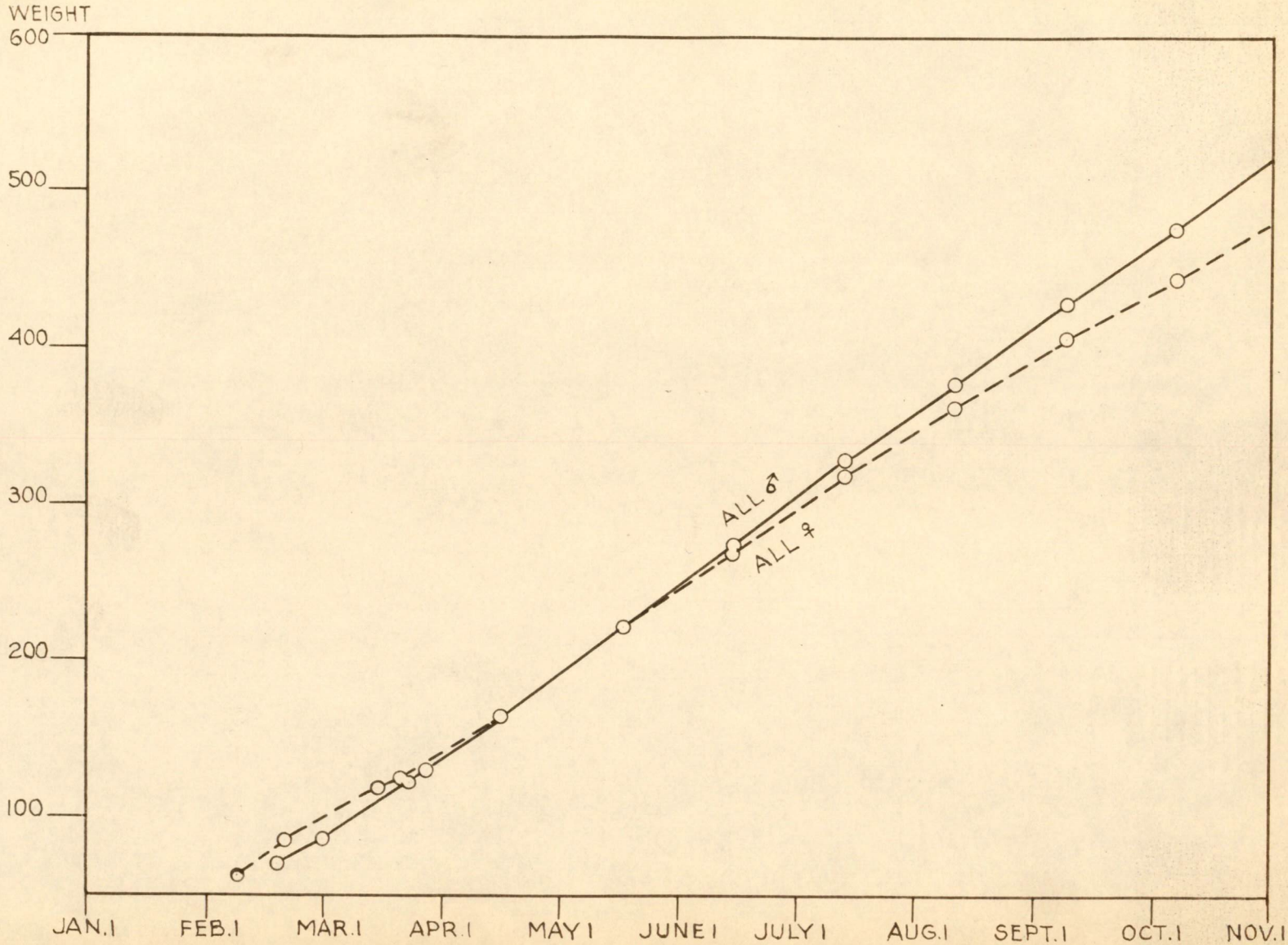

FIG. 6. AVERAGE GROWTH CURVES OF CALVES AT GREENEVILLE 1948,49,50.

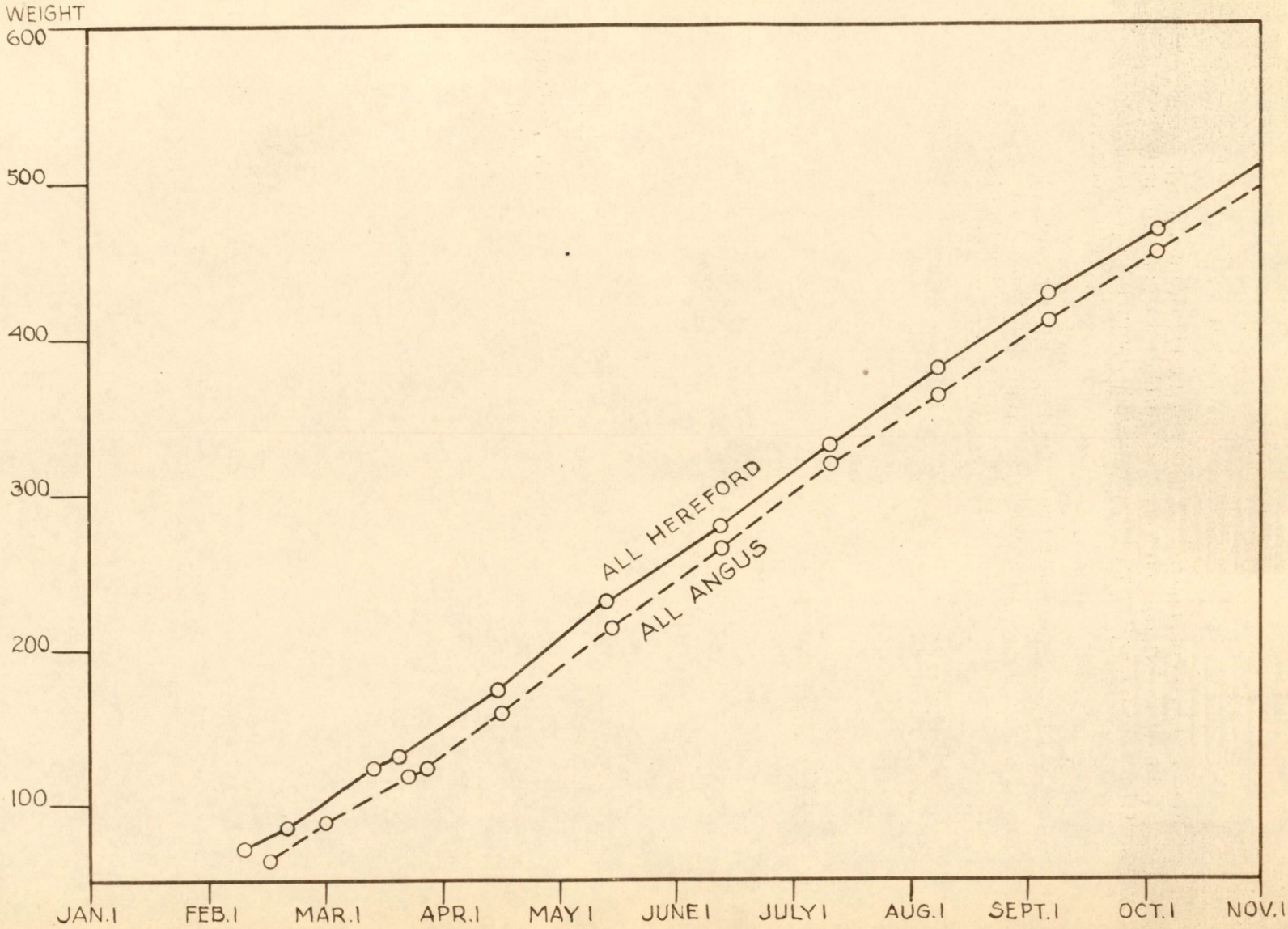

FIG. 7. AVERAGE GROWTH CURVES OF CALVES AT GREENEVILLE 1948, 49, 50.

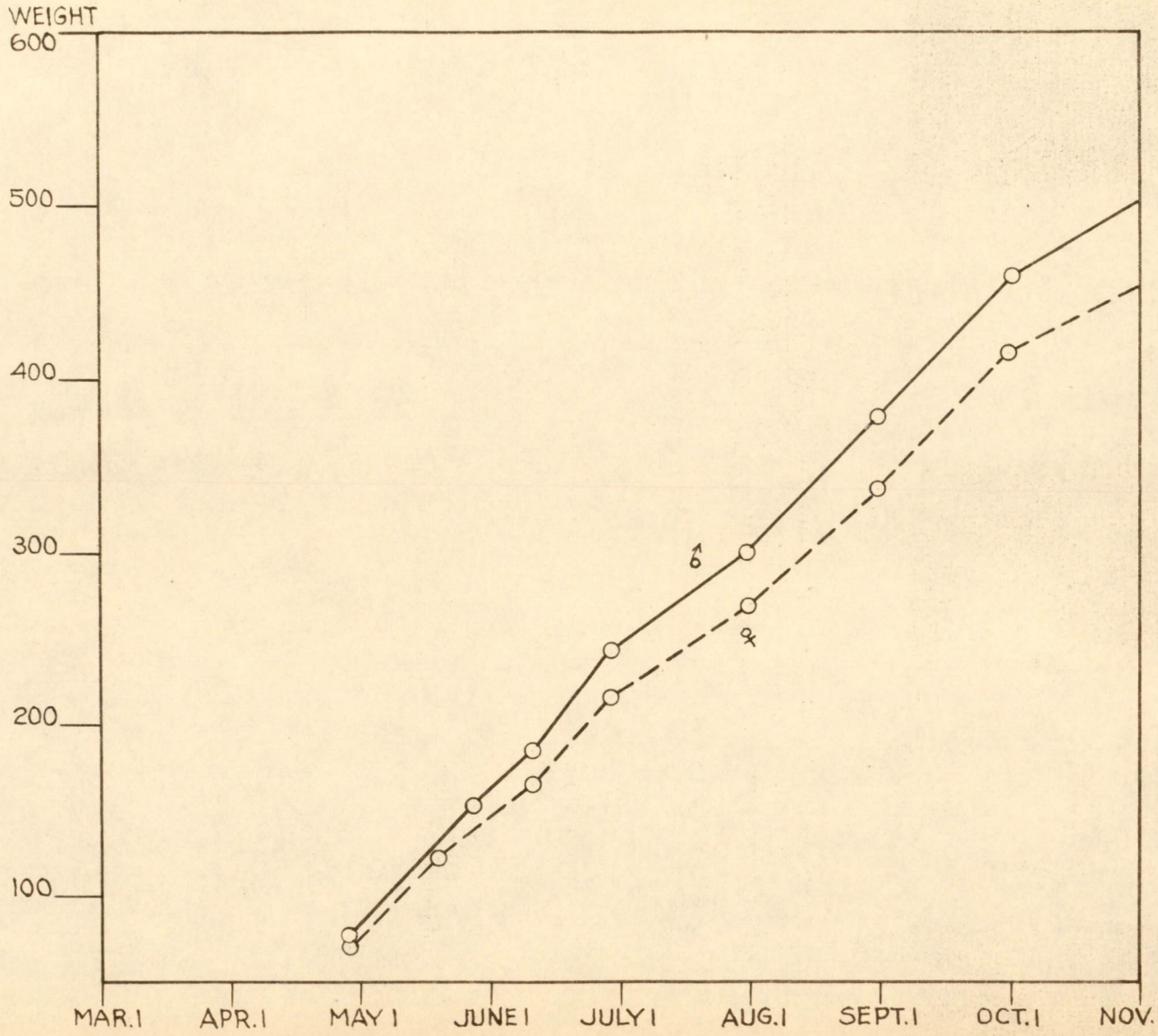

FIG. 8 AVERAGE GROWTH CURVES, CROSSVILLE 1947.

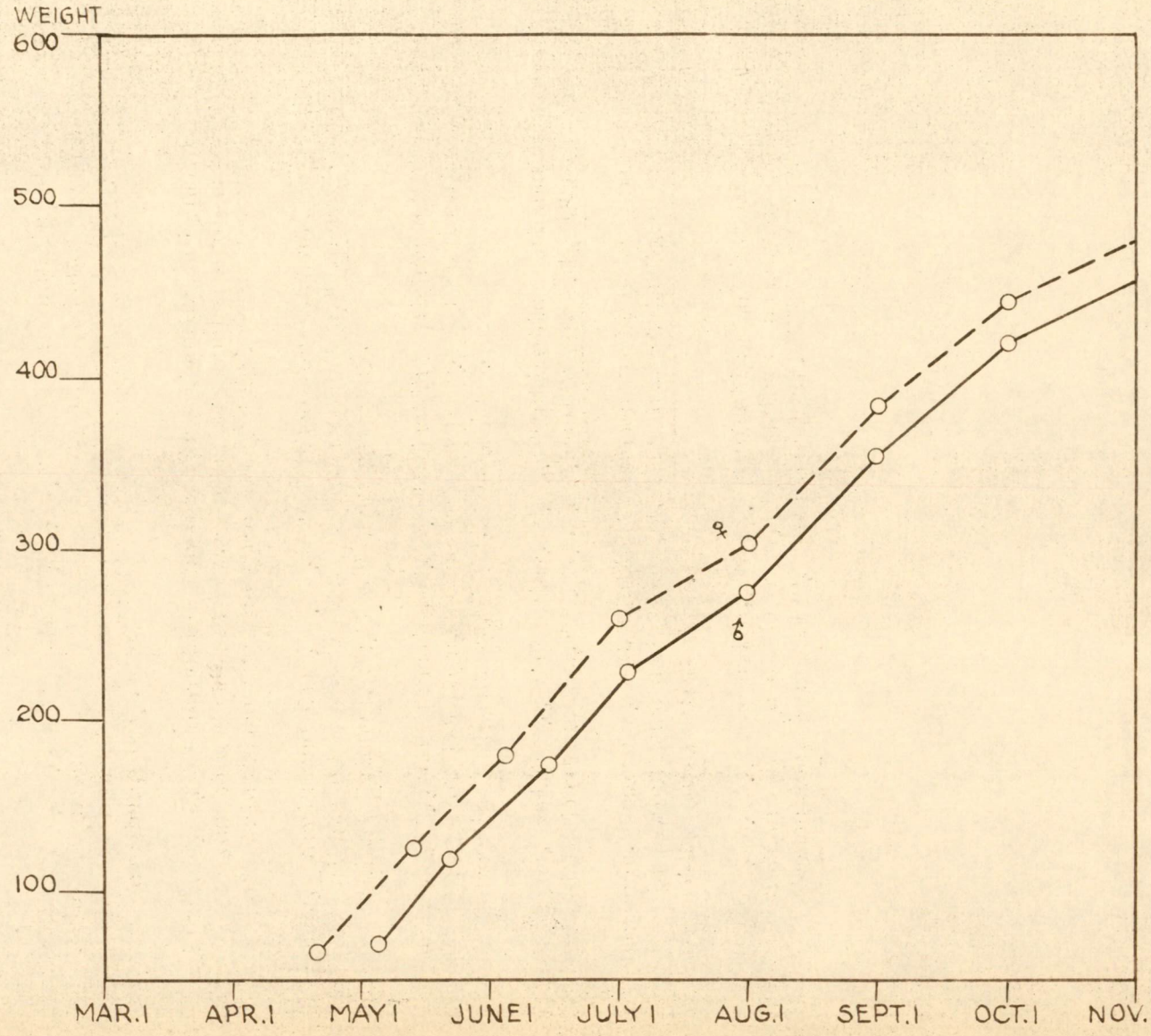

FIG. 9. AVERAGE GROWTH CURVES, CROSSVILLE 1948.

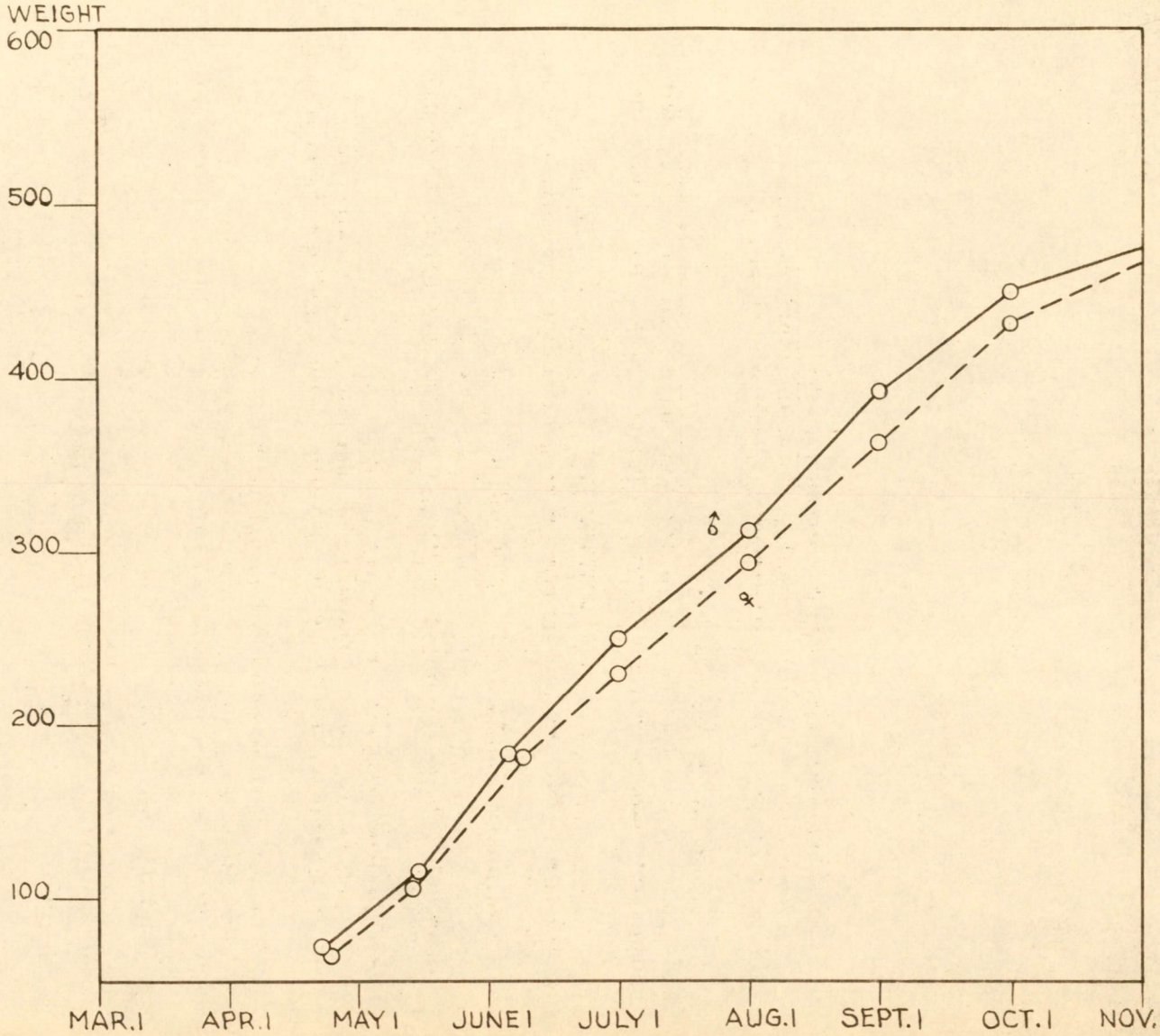

FIG. 10. AVERAGE GROWTH CURVES, CROSSVILLE 1949.

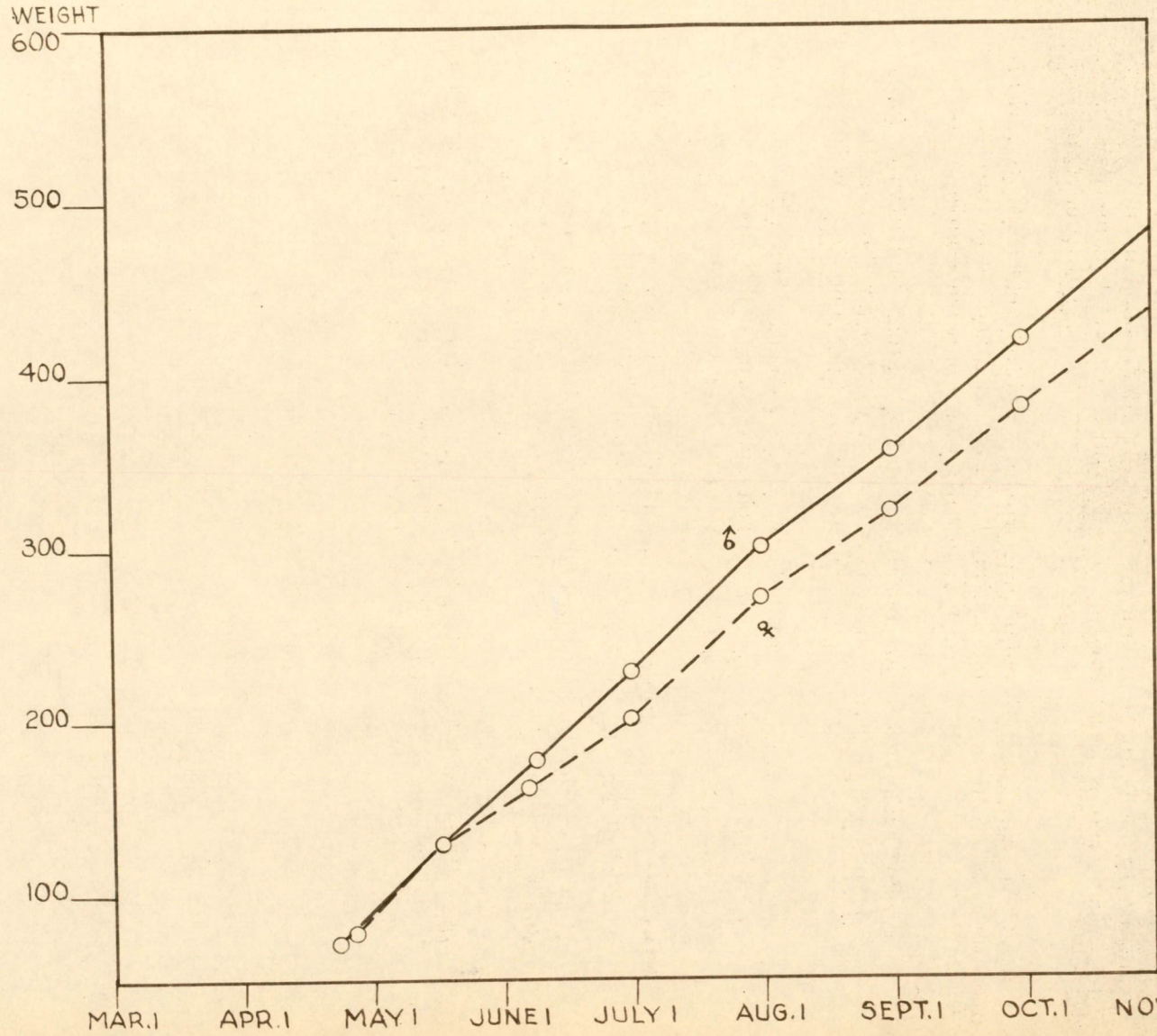

FIG. 11. AVERAGE GROWTH CURVES, CROSSVILLE 1950.

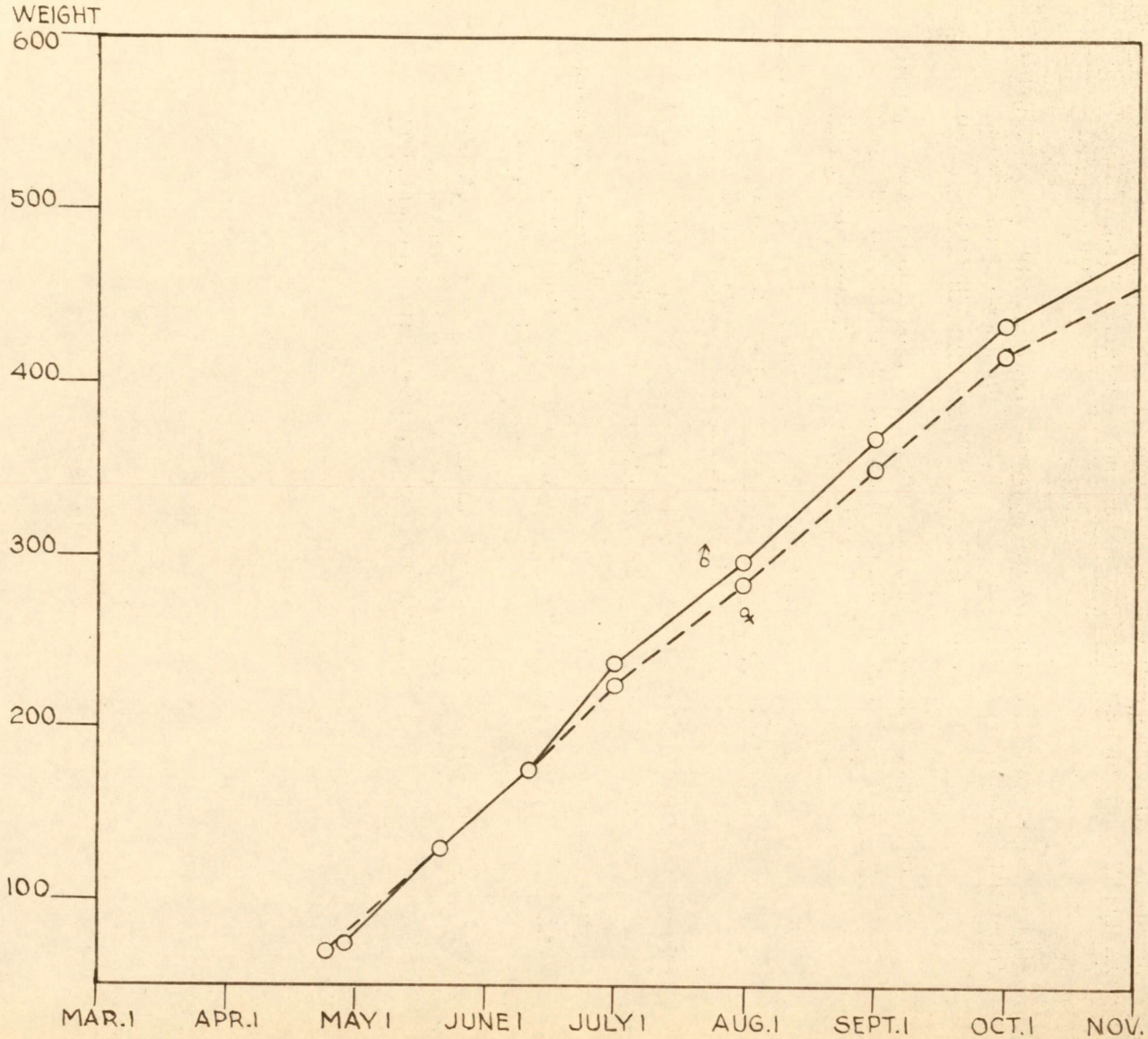

FIG. 12. AVERAGE GROWTH CURVES, CROSSVILLE 1947, 48, 49, 50.

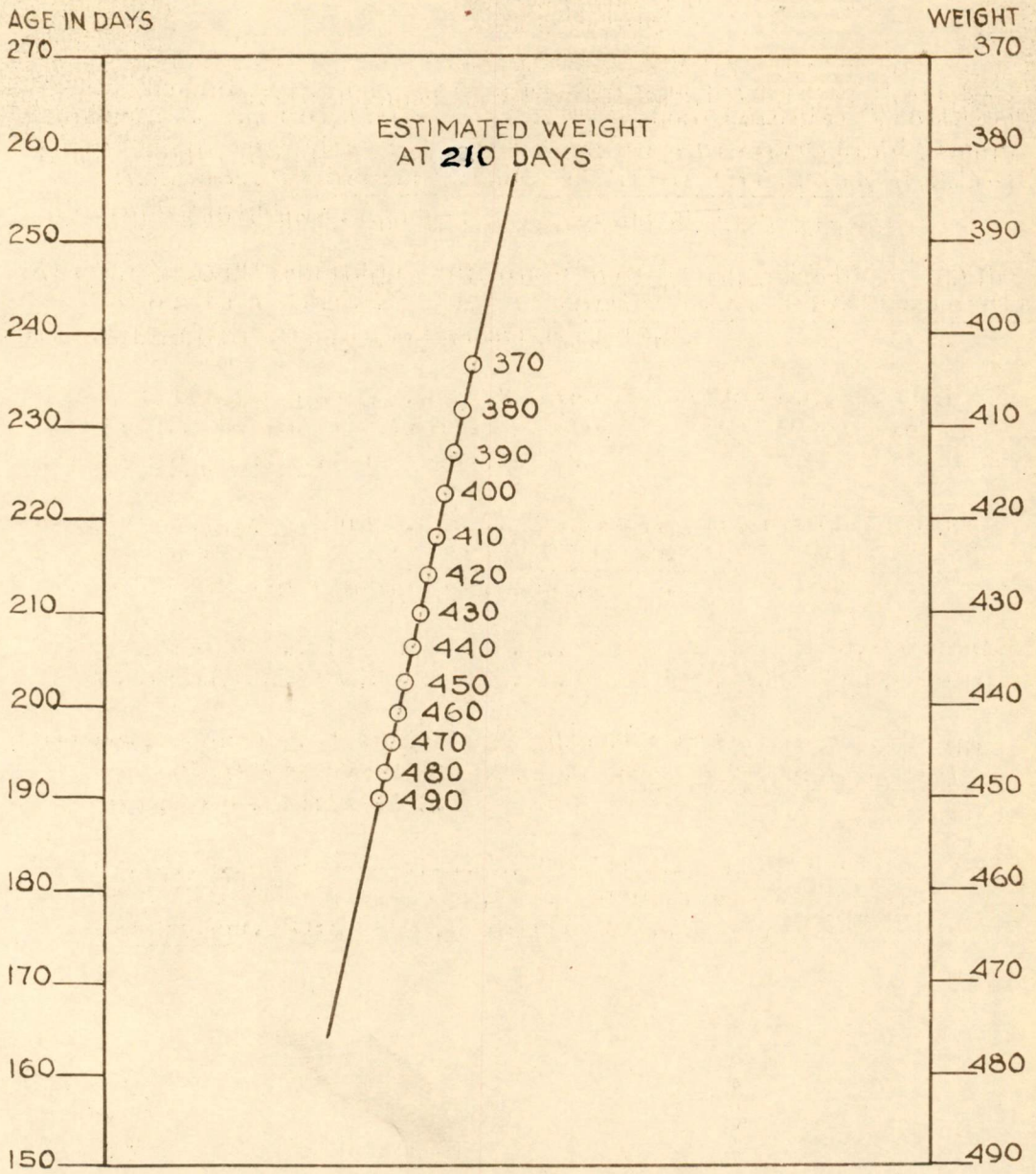

FIG. 13. NOMOGRAPH FOR ESTIMATING WEIGHTS OF CALVES AT GREENEVILLE TO A CONSTANT AGE OF 210 DAYS.

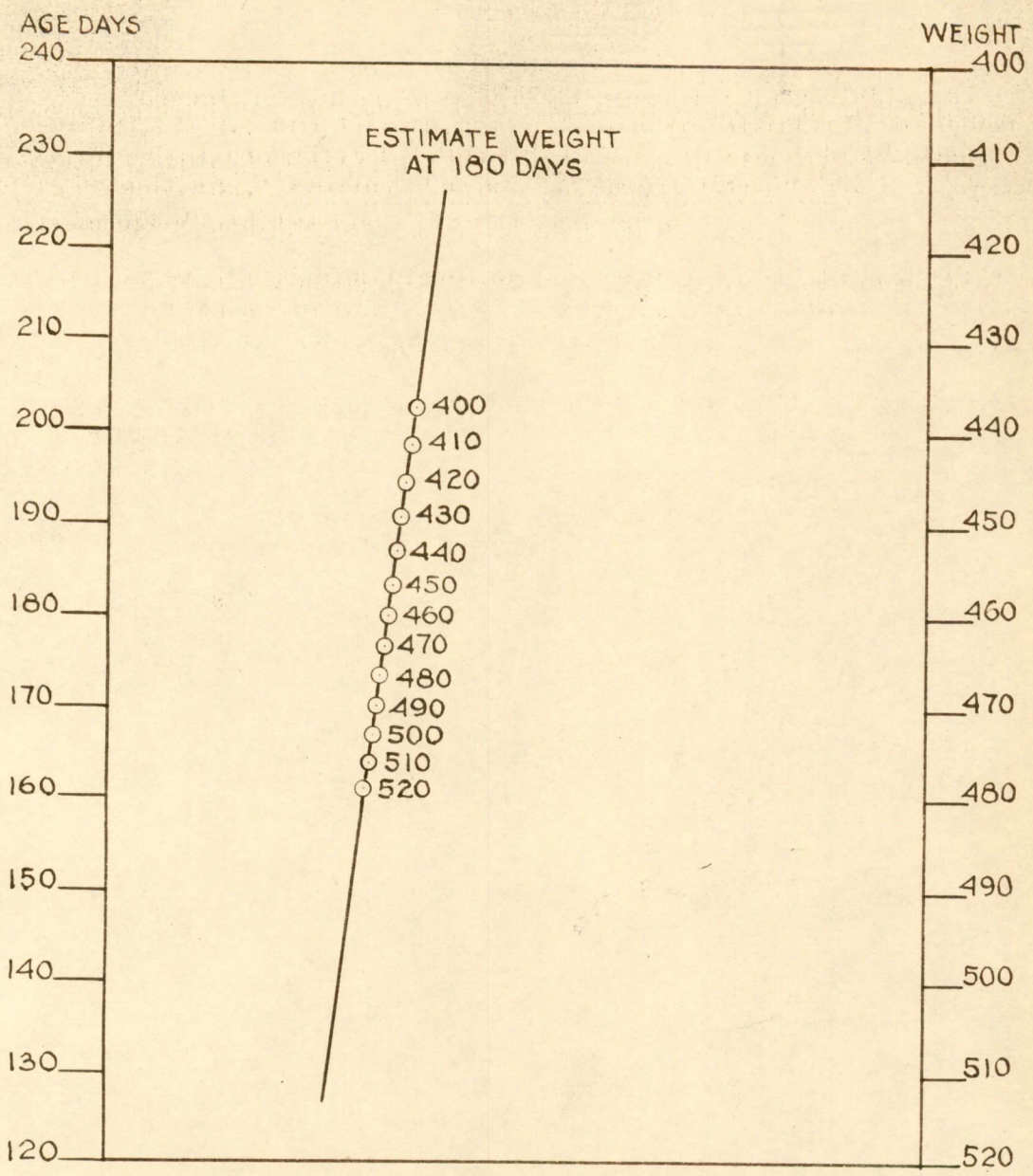

FIG. 14. NOMOGRAPH FOR ESTIMATING WEIGHTS OF CALVES AT CROSSVILLE TO A CONSTANT AGE OF 180 DAYS.