



8-1947

Some Factors affecting the weights of dairy cattle

James Nelson Maddux

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To the Graduate Council:

I am submitting herewith a thesis written by James Nelson Maddux entitled "Some Factors affecting the weights of dairy cattle." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C. E. Wylie, Major Professor

We have read this thesis and recommend its acceptance:

H. R. Duncan, Eric Winters

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

July 1, 1947

To the Committee on Graduate Study:

I am submitting to you a thesis written by James Nelson Maddux entitled "Some Factors Affecting the Weights of Dairy Cattle". I recommend that it be accepted for sixteen quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

L. E. Wylie
Major Professor

We have read this thesis
and recommend its acceptance:

H. R. Duncan

E. Winter

Accepted for the Committee

J. P. Smith
Dean of the Graduate School

SOME FACTORS AFFECTING THE WEIGHTS OF DAIRY CATTLE

A THESIS

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

by

James Nelson Maddux

August 1947



ACKNOWLEDGMENT

The material contained in this thesis was collected and tabulated by the writer at the University of Tennessee from September 1946 to July 1947.

The writer wishes to express his appreciation to Professor C. E. Wylie who directed the study, Mr. S. A. Hinton, for assistance in methods and procedure, and Mr. W. W. Overcast, for advice in the organization and preparation of the thesis.

The writer is deeply indebted to Mr. J. T. Miles for his constant assistance throughout the duration of this study.

Much credit is due Mrs. Sarah Jane Grose who typed this thesis.

J.N.M.

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CHAPTER I

SOME FACTORS AFFECTING THE WEIGHTS OF DAIRY CATTLE

Introduction

The purpose of this investigation is to study some of the factors which affect the weights of dairy cattle. The weight of an animal is very important in that weight is a measure for determining breed standards; it is used to derive feeding formulae; weight is involved in most feeding trials, growth-size studies, gestation experiments and in other dairy research.

Many investigators use the weight of a dairy cow as a criterion of progress or regress in their experimentation. The weight variations of the animals being studied in a given experiment may have been of ample significance to have affected the results materially.

There are several factors which may have an important correlation with dairy cattle weights. Of these factors the following will receive consideration:

Accuracy	Heart-girth variations
Pregnancy	Age
Parturition	Feed
Lactation	Sickness
Temperature	Breed

A study of this nature, supplemented with ample related studies, may well reveal factors which may be constant, quite

variable, highly significant or relatively unimportant. Before beginning a research project an investigator must of necessity decide which factor he wishes to control and which factor he wishes to allow to vary.

A formula will be developed to determine the approximate weight of a dairy animal under field conditions and without the aid of livestock scales.

CHAPTER II

REVIEW OF LITERATURE

Weight Variations

Lush (13) reports that cattle weights fluctuate considerably from day to day. His investigations show as wide a variation as 43 to 77 pounds in eight days. Morrison (16) suggests that the weight of an animal may vary as much as 20 to 40 pounds in a single day. These data place emphasis upon the importance of accurate weights in dairy research.

Accuracy

Numerous authorities, (1), (3), (10), (12), (13), and (16) concur on methods for decreasing inaccuracy in experiments where live weight is a major factor. The animals should be given an adequate fore-period to adjust themselves to the environmental conditions which will be existent in the forthcoming trial. Duplicate lots of animals should be used. The more animals there are per lot the greater the accuracy of the trial. The animals should be weighed on three successive days at the beginning of the trial and at its end. Shrunk weights taken at the same time each day will prove more accurate. The second and third weighings of the animals will eliminate about 42 percent of the experimental error for

each animal which averages 6 to 14 pounds under the most desirable conditions. There are four times throughout the day when animals can be weighed with the resultant weight being a true average for the entire day. These periods are: shortly after feeding in the morning, shortly after feeding in the evening, and during the periods of declining weight which are 11:30 a.m. and 1:00 p.m. Lush and Copeland (12) report that weighing and measuring errors are about the same, amounting to about 2 percent. Baker, et al (2) report that under certain conditions there may not be any increase in accuracy as a result of multiple weighings of calves at weaning time. A three-day average weight of 178 calves at weaning age was only 1.3 pounds less than the average of the first day's weighings. When the first and second weights were averaged this value was 0.9 pound lower than the average for the first day. Lush (13) found that there was much less variation in the weights of calves than in mature animals. However, as the size of the mature cow increases there seems to be no increase in experimental error.

Pregnancy

Eckles (5) showed that on the dry matter basis a Jersey calf was equal to 110-170 pounds of Jersey milk at birth. A Holstein-Friesian calf was equal to 200-270 pounds of Holstein milk at birth.

Morgan and Davis (15) studied 656 parturitions and concluded that a cow will, on the average, gain steadily in weight from conception to parturition.

Mosely, Stuart and Graves (17) studied 53 Holstein cows and found that 94 percent of the gain that occurred from conception to parturition was made during the last five months of pregnancy. The foetus acquires 70 percent of its growth in the last three months.

Putnam and Henderson (18), at the West Virginia Station, studied 56 Ayrshire females and concluded that 75- to 85-percent of the gain due to pregnancy occurred in the last four months of the period.

Parturition

Eyse and associates (6) report from the Iowa Station that first-calf Holstein heifers lost an average of 147 pounds at calving, and first-calf Jersey heifers lost an average of 82 pounds.

Fitch, et al (7) in 1924 reported on all calf weights available. The birth weight average for Holsteins was 90 pounds and for Jerseys 55 pounds. Wylie and Hinton (26) show an average birth weight for Jersey calves to be 48 pounds and for Holstein calves 83 pounds.

Other investigators (17) have shown the average calving losses of Holstein females of all ages to be 158.7 pounds with the average calf weighing 95.2 pounds. Cows in this trial lost weight for 35 days and then began a steady gain throughout pregnancy. Morgan and Davis (15) report that a cow's weight will become stabilized around 45 days after calving.

Lactation

Graves (9) has shown that where two-year-old heifers are fed on a basis of requirements, plus 10 percent, they will gain weight from the first month of lactation throughout pregnancy. In contrast, however, mature cows will on the average, under the same feeding system, maintain their weight during the first seven months of lactation, and they will make rapid gains during the last five months of lactation.

Ragsdale, Turner and Brody (19) state that after the fifth month of lactation there is a rapid decline in milk production. Turner (21) studied the records of 50 high producing test cows and found that a cow in a high-production level will reach her lowest body weight during the third month after calving and will gain weight steadily thereafter throughout the lactation and pregnancy period.

Temperature

Dice (4) suggests 50° F. as an optimum temperature for cow comfort. Other investigators (13) have shown conclusively that a 52° F. drop in atmospheric temperature, coupled with failure of cattle to drink water and eat regularly, caused a weight variation of 43 pounds. Regan and Richardson (20) state that a cow maintains her efficiency of milk production and feed utilization in temperatures ranging from 0° F. to 85° F. Further temperature variations, either

up or down, will materially affect the cow's efficiency. Temperature largely governs (25) the number of times a cow desires water throughout the day.

Heart-girth Variations

That skeletal changes are involved when the weight of an animal changes is shown by Misner (14). His work in the Cornell herd shows a 0.97 coefficient of correlation with actual body weight and heart-girth measurements. The corresponding standard of weight per inch of heart-girth measurement as shown by this authority is 44.7 pounds.

Kendrick (11) has prepared a table for use in estimating the weights of dairy cows from heart-girth measurements. This table is designed for use with calves and also mature animals. Gaines, et al (8) has developed a formula for the estimation of live weight in dairy cows.

Age

In the first three pregnancies gains, due to conception, may be attributed to growth (18) and the products of conception. These investigators have shown also that mature cows will lose a lower percent of conception weight at calving than will heifers. Yet a mature cow will drop larger calves (17) than heifers. Indirectly, then, growth and maturity in the female are the controlling factors

on calf size, pregnancy gains and parturition losses in healthy animals.

Feed

Lush (13) concluded, at the Texas Experiment Station in 1928, that feed was not a factor in the weight variations in cattle, insofar as the nature of the ration is concerned. However, conditions governing feed intake may well be factors of importance.

Breed

Holstein cows drop calves from 70 pounds to well over 100 pounds (18), (26), averaging around 90 pounds. However, Jersey cows drop calves which average 48 to 55 pounds at birth.

Sickness

Data are limited on this factor. They need to be studied further to properly place a value upon the effect on weight variations.

CHAPTER III

EXPERIMENTAL PROCEDURES AND METHODS

The data contained in this thesis were collected at the Tennessee Experiment Station at Knoxville and from certain unpublished data of the Dairy Department which have been secured from the Middle and West Tennessee Experiment Stations since 1937.

The procedure used for the collection of a more detailed type of data at the Knoxville Station during 1946 and 1947 will be discussed first. The animals included were "springing heifers and mature cows", which were registered Jerseys and Holsteins. The average number of animals under consideration was fifty.

The registration papers and herd records were consulted in the beginning to secure pertinent identification data. The identification of each animal included: name, registration number, date of birth, age, breed, ear mark, date of last calving, dates of breeding, dates of drying off and state of lactation. All weighings were made on the stock scales at the University of Tennessee Barn No. 1. All lactating cows were weighed once each month on the first Friday. The cows were consistently weighed from 8 a.m. to 10 a.m. All dry cows and springing heifers were weighed weekly for six weeks prior to calving and six weeks after calving on each Friday morning.

After the cows dropped their calves they were weighed within two and one-half days. The calf was weighed within twenty-four hours

after being dropped. Floor scales were used to weigh all the calves. The milk produced on the day the cow was weighed was considered as her production and tabulated accordingly. These data were collected once each month.

Temperature and humidity readings were taken each Friday at the time corresponding to the time the cows were weighed. The official weather report of the U. S. Weather Bureau at Alcoa, Tennessee, was used as a source of these data.

A standard cotton tape, graduated to one-fourth inch, was used in taking the heart-girth measurements of all animals. New tapes were used from time to time to insure accurate readings.

Once each month the hay, silage and concentrates were weighed. This procedure involved weighing the feed offered and the feed refused in the course of 24 hours. These data were taken on the day the lactating cows were weighed. An appropriate form was designed for recording the data and was bound so as to make a permanent record.

The monthly reports of the Middle and West Tennessee Experiment Stations were examined from 1937 to 1947 in order to tabulate such data as would concern this study. The breed represented at the above Stations was the Jersey. On the average this study involved 35 cows at the Middle Tennessee Station and 25 cows at the West Tennessee Station.

The statements concerning feed and temperature, on pages 33 and 34, apply to the study made at Knoxville. The experimental error for this study amounted to four pounds (\pm 2 lbs.). All variations amounting to less than this value are therefore insignificant.

CHAPTER IV

DISCUSSION OF RESULTS

Weight Changes at Parturition

In the course of this study nine Jersey cows dropped calves. Table I presents a summary of the results of those parturitions. The group included two first-calf heifers. The average weight of the cows prior to calving was 1003.1 pounds and their weight after calving was 889 pounds. The total calving loss averaged 114.1 pounds. The average weight of all calves was 60.5 pounds while "other losses" amounted to 53.6 pounds. The eleven-year average birth weight of 252 Jersey calves dropped in the Middle Tennessee Station herd from 1936 to 1946 was 53.3 pounds. This figure is in accord with the value of 54 pounds given by Wylie and Hinton (26), which is an average of the weights of 48 calves. The percent of body weight lost at parturition was 12.95, where the after-calving weight is considered as normal weight. This percentage agrees closely with data reported by Fitch, et al (7) whose data show a group of 418 Jersey cows with after-calving weights of 877 pounds. Graves (9) showed that for Jerseys and Holsteins the average loss at calving was 1/8 of the after-calving weight.

Of the nine Jersey cows listed in Table I, only two were first-calf heifers. Their after-calving weights were considerably below the Jersey breed standard of 950 pounds. Two of the animals approached

TABLE I
WEIGHT CHANGES AT PARTURITION
(JERSEYS)

Name of animal	Age at calving	Weight prior to calving (lbs.)	Weight after calving (lbs.)	Total loss (lbs.)	Weight of calf (lbs.)	Other losses (lbs.)	Loss in body weight (percent)
Kathleen	5-1	960	806	154	69	85	19.10
Sunshine	13-8	1200	1105	95	54	41	8.68
Sophie	4-6	930	840	90	53	37	10.70
Matilda ^a	2-10	942	841	101	54	47	12.00
Ann	8-10	1090	961	129	70	59	13.40
Nelly ^a	4-0	1060	956	104	57	47	10.87
Phoebe	2-8	838	712	126	63	63	17.70
Pricilla	4-10	886	780	106	60	46	13.60
Countess	6-8	1122	1000	122	65	57	12.20
Average		1003.1	889	114.1	60.5	53.6	12.95

^aFirst-calf heifers.

the breed standard rather closely. Cows, Ann and Nelly, had after-calving weights of 961 and 956 pounds, respectively. Two other animals were well beyond the breed average with weights of 1105 pounds and 1000 pounds. The group averaged 61 pounds less than the breed standard. A dairy cow's weight will not remain constant for very many days. For this reason it would be of considerable value to breeders and to breed associations to know what the average weight for a Jersey cow should be at a particular time during pregnancy, lactation and the dry period.

Table II summarizes parturition losses as they are affected by the age of the cow. A total of 163 parturitions over a ten-year period were involved. The Jersey herds at the West, Middle and East Tennessee Experiment Stations were used in the study. First-calf heifers averaged a loss of 98.30 pounds. Second-calf heifers lost 116.40 pounds and mature cows lost 109.50 pounds at calving. The increase in parturition losses with the second calf may be attributed to the fact that cows drop larger calves each succeeding parturition and are gaining weight. Though mature cows do drop larger calves than heifers, their "other losses" decline with increasing age in normal animals and they are not growing (18). These data agree closely with results reported by Mosely, Stuart and Graves (17).

TABLE II

PARTURITION LOSSES AS AFFECTED BY AGE OF COW

(JERSEYS)

Station	Number of parturitions	First calf (lbs.)	Second calf (lbs.)	Aged cows (lbs.)
Jackson	67	107.5	121.6	111.6
Columbia	87	90.5	115.2	106.5
Knoxville	9	113.5	97.0	121.2
Average		98.30	116.40	109.50

Table III summarizes the calving records of the Knoxville, Columbia and Jackson Jersey herds for a ten-year period. A total of 209 parturitions were tabulated. The resultant average in calving losses at parturition was 109.92 pounds. This loss is some four pounds less than the average secured from 1947 data (table I) in the herd at Knoxville.

The variation of the mean values of 107 pounds to 114.1 is not significant in that the time of collection of the original data may have varied widely between the Station at Knoxville and the other two Stations.

A detailed calving record was tabulated on several cows in the Holstein herd at Knoxville. A summary of these results is shown in Table IV. The seven Holstein cows shown in this table averaged 1450.8 pounds prior to calving and immediately after they dropped calves their average weight was 1233.4 pounds. The average size calf was 91.86 pounds, while the total loss due to calving averaged 217.4 pounds. The three first-calf Holstein heifers shown in Table IV (Princess, Bernice and Nadine) had a calving loss which averaged 146 pounds. This value is in accord with the work of Epse (6) of Iowa who reported a loss of 147 for the same age group and breed. Cows 303 and 245 were sick at parturition. This condition, when averaged with this small number of cows, shows an unusually high loss in body weight at calving. Excluding these two animals the total loss at calving would be 175.6 pounds and the average percent lost in body weight would be 14.2 rather than

TABLE III

AVERAGE PARTURITION LOSSES PER COW

(1937-47)

Station	Number of parturitions	Breed	Years	Average total loss (lbs.)
Jackson	114	Jersey	10	111.8
Columbia	86	Jersey	7	107.0
Knoxville	9	Jersey	1	114.1
Total	209			
Average				109.92

the figure shown which is 17.6 percent. The amniotic fluids and other products of conception averaged 125.57 pounds per animal.

When giving an average weight for a dairy animal that value should be placed on the cow when she is at work (during the lactation period). This opinion is based on the writer's study and observations. Conclusive results have not been obtained which would set a standard of body weight for a cow at a definite time in the lactation period. The average weight of the seven Holstein cows represented in Table IV is lowered considerably by the lack of maturity of four cows in the group.

As shown in Table IV, cow 245 dropped twins with an average weight of 58.5 pounds, and due to unavoidable circumstances Dixie's calf was not weighed; therefore, its weight was estimated. Cows 303 and 245 were sick at parturition.

Graves (9) found that some of the two-year-old Holstein heifers lost as much as 13.7 percent of their body weight at calving. Mosely (17) concluded that the average total loss from Holstein females from the ages of 2-6 years in the Huntly, Montana, Station herd was 158.7 pounds. Epse (6) of the Iowa Station found the average total loss by two-year-old Holstein heifers to be 147 pounds at calving.

TABLE IV
WEIGHT CHANGES AT PARTURITION
(HOLSTEINS)

Name of animal	Age at calving	Weight prior to calving (lbs.)	Weight after calving (lbs.)	Total loss (lbs.)	Weight of calf (lbs.)	Other losses (lbs.)	Loss in body weight (percent)
Pearl	4-6	1610	1390	220	92	128	15.8
Princess	2-6	1272	1160	112	77	35	9.6
Bernice	2-7	1190	1040	150 ^b	77	73	14.4
303	11-0	1770	1440	330 ^b	104	226	22.9
Nadine	3-6	1376	1200	176 ^b	94 ^c	82	14.6
245	17-5	1388	1074	314	117 ^c	197	29.5
Dixie	6-5	1550	1330	220	82 ^a	138	16.5
Average		1450.8	1233.4	217.4	91.86	125.57	17.6

^aEstimated.

^bSick at parturition.

^cTwins.

The Effect of Parturition on
Heart-girth Measurements

Apparently parturition is highly correlated with heart-girth measurements. Table V shows chest variations for Jersey and Holstein females when the values are at their widest points. The declining variation lags behind calving by several days. There was no apparent difference between the breeds. The widest variation averages occurring 24.55 days after calving for the Jerseys as compared to 25.3 days for the Holstein females. The heart-girth measurements fluctuated from 3 inches to 7 inches with an average of 5.21 inches for 16 cows at 24.97 days after calving. Mosely (17) concluded that cows would begin to gain weight during the fourth week (22-28 days). These cows were going through normal lactations and through a normal breeding program. Turner (21) observed 50 Illinois test cows and concluded that on a high-production level a cow would lose some weight for 90 days following calving. It should also be noted here that a delayed breeding program was practiced with this herd.

Two Jersey cows and one Holstein cow exhibited heart-girth losses that were considerably below the average for 17 animals. The two Jersey cows are small cows for the breed. Pricilla weighed 886 pounds prior to calving and Phoebe (a first-calf heifer) weighed 838 pounds before calving. Lack of maturity and a generally small body may explain partially just why they were below the average in heart-girth decline. On the other hand the Holstein cow (Dixie) meets the

TABLE V

THE EFFECT OF PARTURITION ON
HEART-GIRTH MEASUREMENTS

JERSEYS	Widest variation after calving (inches) (loss)	No. days after calving	HOLSTEINS	Widest variation after calving (inches) (loss)	No. days after calving
Kathleen	7.0	36	Pearl	4.5	11
Sunshine	5.5	32	Princess	6.5	18
Sophie	6.0	30	Bernice	6.5	10
Matilda	5.5	29	303	6.0	11
Ann	4.5	38	Nadine	3.5	30
Nelly	5.0	18	245	6.0	19
Phoebe	3.5	25	Dixie	3.0	18
Pricilla	3.5	7			
Countess	7.0	6			
Average	5.28	24.55		5.14	25.3
Av. J/H	5.21	24.97			

weight standards for her breed quite closely. Her weight was 1550 pounds prior to calving and 1330 pounds after calving. Her age was 6 years and 5 months at calving. All these cows were in good condition during this trial.

Average Monthly Weight Variations of Lactating Cows

A study was made of the average monthly weight variations per lactating cow in the Middle and West Tennessee Experiment Station herds. These herds consisted of Jersey cows ranging in age from first-calf heifers to and including mature cows. A summary of this study is shown in Table VI. The results are also presented in graphic form in Figure 1. A ten-year average of the December weights of 60 Jersey cows in the Columbia and Jackson herds was considered as the basic value in Figure 1 in determining the cumulative trend in monthly gains.

The original herds were replaced by young animals (first-calf heifers) as the situation warranted. In the course of ten years both Stations had replaced their herds more than twice. Such a program is not unlike farm conditions in this respect. As heifers replace aged cows a common effect is therefore achieved in the final averages shown in Figure 1. A dairy cow will make monthly gains in weight for two reasons: (1) for growth and (2) for reproduction. The combined yearly gains are presented in graphic form as a partial explanation of, and in conjunction with, Figure 2.

The cows lost weight at Columbia in February, July and

TABLE VI

AVERAGE MONTHLY WEIGHT VARIATIONS PER LACTATING COW

TENNESSEE EXPERIMENT STATION

(1937-47)

Month	MTES	WTES	Average two stations
	1938-44 35 cows	1937-44, 46-47 25 cows	
January	0.0	+ 1.0	+ 0.5
February	- 3.0	+ 11.0	+ 4.0
March	+ 4.0	- 14.0	- 5.0
April	+ 11.0	+ 26.0	+ 18.5
May	+ 32.0	+ 44.0	+ 38.0
June	+ 9.0	+ 8.0	+ 8.5
July	- 5.0	- 5.0	- 5.0
August	+ 6.0	+ 29.0	+ 17.5
September	+ 27.0	+ 6.0	+ 16.5
October	+ 20.0	+ 4.5	+ 12.25
November	- 2.0	+ 10.5	+ 4.25
December	+ 6.0	+ 20.5	+ 13.25

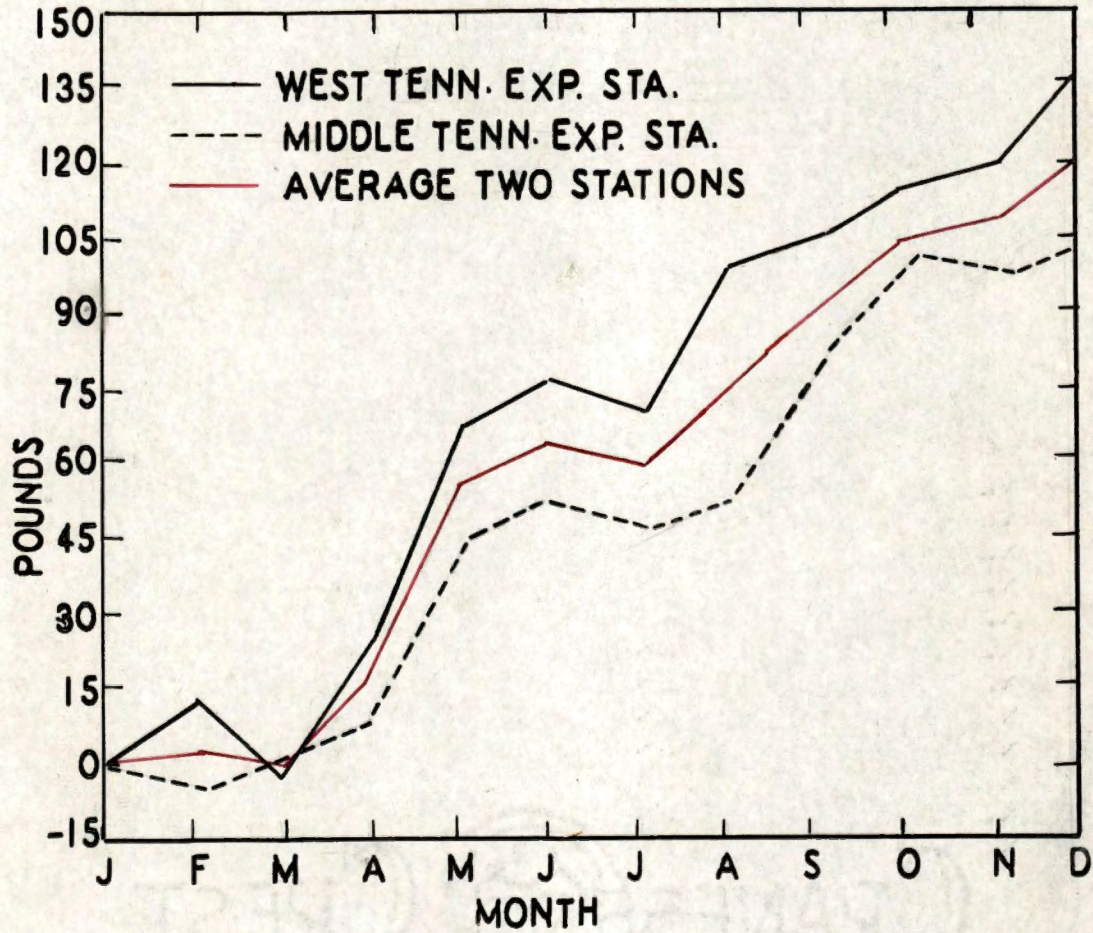


FIGURE 1

TREND OF AVERAGE GAINS PER LACTATING COW BY MONTHS, 1937-46.

November. In January their weight was constant. This herd gained weight noticeably in April, May, September and October. The West Tennessee herd lost weight heavily in March and also in July. This group of cows made the heaviest gains in April, May, August and December. An average of the weight variations of these two herds shows a loss in body weight of 5 pounds in March and also a loss of 5 pounds in the month of July. There is a gain in weight beginning in August and extending through February on the average. The March loss is made up in April, May and June. Figure 1 shows only net gains over a twelve-month period. This can be clarified by the fact that calving losses were not included in this graph. The average net gain from the two Stations, from all cows, was 123.3 pounds per year. Since cows of all ages were included in this study this annual gain per cow has a high correlation with the data shown in Table III. After deducting the average calving loss of 110.96 pounds from the net gain shown above, the difference of 12.29 pounds may be attributed to heifer growth.

The Effect of Pregnancy, the Dry Period and
Lactation on the Weights of Cows H-8 and W-43

Figure 2 shows the effect of pregnancy, the dry period and lactation on the weights of dairy cows H-8 and W-43 for a period covering six lactations from each cow. Data were collected from these two cows since more lactations had been completed by these animals than by the other animals. These animals were owned by the West Tennessee Experiment

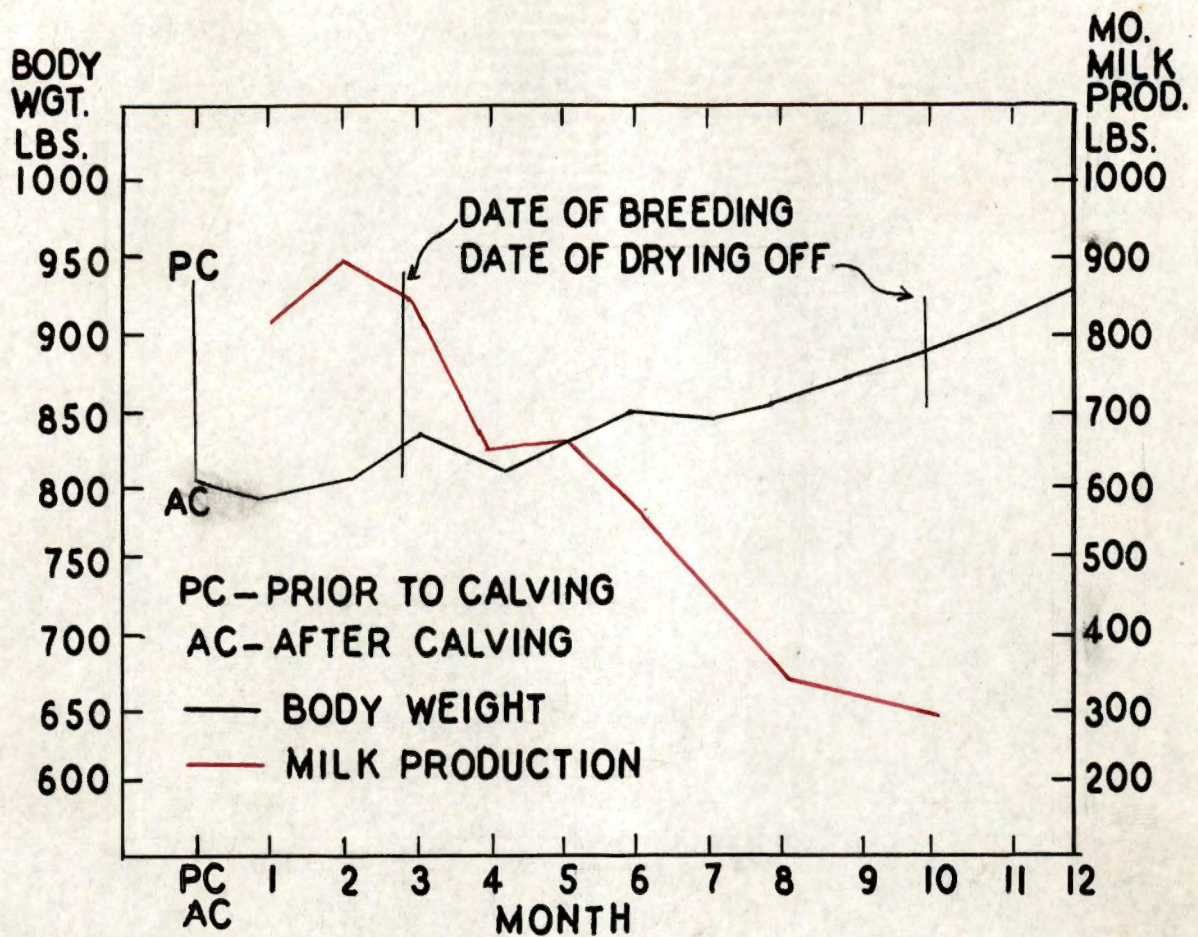


FIGURE 2

THE EFFECT OF PREGNANCY, THE DRY PERIOD AND LACTATION

ON THE WEIGHTS OF COWS H-8 AND W-43^a

^aAverage of six lactations each.

Station at Jackson, Tennessee. At the end of the first month of lactation the cows were producing an average of 810 pounds of milk per month. The highest peak of production was reached during the third month when an average of 892 pounds of milk was produced. At the end of the fourth and fifth months the production was 644 pounds and 661 pounds, respectively. The production dropped 81 pounds the sixth month, 129 pounds the seventh month, 93 pounds the eighth month, 124 pounds the ninth month and 30 pounds the tenth month. The cows were giving an average of 10.13 pounds of milk per day when the drying-off period was begun.

Before calving the cows showed an average weight of 933 pounds as compared to 802 pounds after calving. For the next twelve months, which includes the dry period, the average weights of the two animals were as follows: 791, 802, 835, 810, 830, 843, 845, 855, 871, 891, 910 and 937, pounds. The total calving loss for the two cows averaged 131 pounds. Over a period of twelve months these cows averaged gaining 135 pounds. This period of time involves a complete cycle of weight changes in a dairy cow from one calving until another calf is due. Figure 2 shows a progressive gain in weight from one month after the cow is bred until the cow is due to drop the calf. Other authorities (9), (19), and (21) are in agreement with the results obtained in this study.

After the fifth month of lactation there is a sharp decline in milk production. Possibly the decline in milk flow is due to the demands (5) of the developing foetus for nutrients. Cows in this study

gained 92.1 percent of their pregnancy gains during the last five months of the gestation period. This figure agrees closely with the results of investigations made at the Huntly, Montana, Field Station (17).

West Virginia experiments (18) show that Ayrshire females gained an average of 80 percent of their total pregnancy gain in the last four months of gestation. Results of the study conducted by the writer reveal a gain of 79.5 percent for a similar period. In the last three months of pregnancy the gain amounted to 64 percent of the total pregnancy gain. Other investigators (17) concluded that the gain for a similar period would be approximately 70 percent. Their data also indicate that the total gain from conception to calving will be about one-seventh of the conception weight of the cow. The animals represented in Figure 2 gained about one-eighth of their conception weight on the average during pregnancy. Graves' (9) results are in agreement with the results secured from this investigation on conception gains.

The lactation-pregnancy weight cycle of 64 Jersey cows is presented in Table VII. A total of 155 lactations is represented in this study. The average weights of two cows is shown in the table for the purpose of comparing data on six cycles with a larger number of animals with fewer lactations.

The lactation-pregnancy cycle may be described as the time intervening from the time one calf is dropped by a dairy cow until that cow is ready to drop her next calf.

TABLE VII
LACTATION-PREGNANCY CYCLE OF MONTHLY
WEIGHTS OF JERSEY COWS

Item	GROUP I		GROUP II	
	Average body weight (lbs.)	Percent of true ^b weight	Average body weight (lbs.)	Percent of true weight
Number of cows	2 ^a		64 ^c	
Before calving	933	111.7	887	114.7
After calving	802	96.1	779	101.0
End of 1st month	791	94.8	779	101.0
End of 2nd month	802	96.1	770	99.6
End of 3rd month	835	100.0	773	100.0
End of 4th month	810	97.1	775	100.2
End of 5th month	830	99.5	776	100.4
End of 6th month	845	101.2	793	102.5
End of 7th month	843	101.1	803	103.8
End of 8th month	855	102.4	814	105.3
End of 9th month	871	104.3	827	107.0
End of 10th month	891	106.7	841	108.7
End of 11th month	910	109.0	851	110.1
End of 12th month	937	112.2	852	110.2

^aAverage of two Jersey cows (H-8 and W-43), twelve lactations.

^bTrue weight = weight at the completion of the third month of lactation.

^cAverage of sixty-four Jersey cows, one hundred fifty-five lactations, Jackson and Columbia Stations (1936-46).

Cows H-8 and W-43 had losses at calving amounting to 15.6 percent of their after-calving weight. At the end of twelve months the same animals regained 16.1 percent of their after-calving weights on 103 percent of their loss in weight at calving.

Group II showed a 13.7 percent loss in weight at calving, based on the after-calving weight value. At the end of twelve months the average cow in this group regained about 70 percent of the weight which was lost at calving.

Group I was at its lowest weight at the end of the first month of lactation, while Group II reached its lowest weight at the end of the second month of lactation.

Group II also made progressive gains from the second month of lactation with subsequent calving. Group I consisted of a small sampling of animals, hence the losses in weight presented in the fourth and seventh months are absorbed when the larger group of animals is considered. The gain of 33 pounds in the third month by Group I is somewhat large for the stage of lactation and at a time just prior to being bred.

Other Factors Related to Weight

Variations in Dairy Cattle

Feed. In this study all lactating Jersey cows were fed concentrates at the rate of 1 pound to each 3 pounds of milk produced. The milking Holstein cows were fed 1 pound of grain to each 4 pounds of milk produced. The dry cows received no grain.

All animals were given the same kind of pasture, the same kind of hay and the same kind of silage. The pasture rates were ad lib. Hay was fed at the rate of 1 pound to each 100 pounds of live weight and silage was fed at the rate of 3 pounds to each 100 pounds of live weight.

The factor of feed in this study is considered as constant since the cows were fed by a sliding standard that would be essentially the same for all animals in that it allows for body weight, stage of pregnancy and level of milk production.

Lush(13) concluded that the nature of the ration had no appreciable effect on the experimental error of cattle weights.

Temperature. Temperature has a very definite indirect effect upon cow comfort (4) which in turn governs the drinking habits of the animal (25). Milk production is influenced by water consumption and live weight is definitely correlated with the level of milk production.

The temperature ranged from a minimum of 24° F. to a maximum of 73° F. during this investigation. All the animals were subjected to the same atmospheric conditions. Such a condition is herein considered as a constant factor for the entire cow group since each animal was subjected to all weather variations without exception.

From 1902 to 1938 the average temperature for Tennessee was 59.12° F. (22). The minimum and maximum temperatures for cow comfort are 0° F. to 85° F. as reported by Regan and Richardson (20) of the California Station. This study does not include extreme weather values and therefore is considered as a constant factor.

Sickness. Table IV shows the weight of two cows which were sick at parturition. The average weight losses of the Holstein cows in normal health was 175.6 pounds. Cows 303 and 245 lost 330 pounds and 314 pounds, respectively, at calving. The average loss in weight of the two animals amounted to 322 pounds. Therefore, the loss, due to sickness alone, was 145.4 pounds. Cow 303 was eleven years of age at her last parturition, and cow 245 was seventeen and a half years of age at calving. Sickness can cause wide variations in the weights of dairy cows. Cow 303 lost 452 pounds due to calving and sickness in a 5-months period.

The Determination of Live Weight in Dairy Cows

Gaines (8) derived the following formula for the determination of live weight in dairy cows:

$$W = .342 (G + g) \text{ raised to the } 1.85 \text{ power.}$$

An explanation of the formula is as follows:

W—live weight in pounds.

G—actual chest girth in inches.

g—girth modifier for age and breed of cow.

Kendrick (11) of the U. S. Bureau of Dairy Industry, has developed a table of standards which may be used in the estimation of the live weights of animals having chest measurements from 26 inches to 92 inches. More than 100 individual values must be used from the table of standards described above, in order to calculate the weights of mature animals having chest measurements between 60 and 87 inches.

Other research (14) has shown that an 0.97 correlation exists between heart-girth measurements and the live weight of a dairy cow. Other results of the same investigation indicated an increment of body weight per inch of heart-girth measurement amounting to 44.7 pounds. Kendrick (11) employed increments of weight ranging from 31 pounds at a 60-inch heart-girth to 46 pounds at a 92-inch heart-girth.

In order to establish an average increment of weight per inch of heart-girth increase, the writer assembled data on the parturition weight losses of nine Jersey and six Holstein cows at the East Tennessee Experiment Station in 1947. These data are shown in Table VIII. The average heart-girth variation was 5.3 inches per cow for both breeds. The average decrease in weight per inch of heart-girth decrease was 39.64 pounds.

The following formula is proposed for the rapid and accurate determination of live weight in mature dairy cows:

$$BW = K \leftarrow (Hg - C)(40) \pm 15$$

An explanation of the formula is as follows:

BW--body weight in pounds.

K--constant value of live weight in pounds (Table IX).

C--constant values of heart-girth measurements given in multiples of five inches (Table IX).

40--increment of weight per inch of increase in heart-girth measurement above "C".

Hg--actual heart-girth measurement in inches.

± 15 --condition modifier based on the degree of fleshing of the animal undergoing estimation.

TABLE VIII

DECREASE OF WEIGHT PER INCH OF VARIATION IN
HEART-GIRTH MEASUREMENT

Name of cow	Heart-girth variation (inches)	Loss in weight (lbs.)	Decrease of weight per inch of variation
Kathleen	7.0	210	30.0
Sunshine	5.5	246	44.7
Ann	4.5	192	42.6
Matilda	5.5	136	24.7
Nelly	5.0	198	39.6
Pearl	4.5	270	60.0
Princess	6.5	256	39.4
Bernice	6.5	150	23.1
245	6.0	312	52.0
Sophie	6.0	224	37.3
Phoebe	3.5	126	36.0
Pricilla	3.5	106	30.3
Countess	6.0	244	40.6
303	6.0	286	47.6
Nadine	3.5	196	56.0
Average	5.3	210.1	39.64

In Table IX are given the standard weights for several heart-girth measurements, according to Maddux and Kendricks (11). For a cow having a chest measurement of 65 inches 800 pounds is used as the standard weight, due to the fact that this is identical with Kendricks' (11) standard. The value of 1200 pounds is used for a dairy animal having a chest measurement of 75 inches because it equals and slightly exceeds the corresponding value employed by Kendricks (11).

For convenient usage the writer's value of 39.64 pounds (Table VIII), for weight increment per inch increase in heart-girth measurement, was converted to 40 pounds. This value is a reasonable figure when compared to Misner's (14) value of 44.7 pounds and Kendricks' (11) range in values of 31 to 46 pounds in mature animals.

Based on the principle of increasing the weight of a mature animal 40 pounds for each inch of increase in chest measurement, there would be a 200-pound increase in weight with each corresponding increase of 5 inches in heart-girth, as shown in Table IX. The values of 1000, 1400 and 1600 pounds were therefore developed from the above principle.

The additional 30 pounds (± 15 lbs.) is incorporated at the end of the formula to adjust the weight of an animal under estimation to its particular condition.

If this formula can be shown to be dependable it could be used to determine the weight of a cow having a heart-girth measurement of $73 \frac{3}{4}$ inches and being in desirable condition, as follows:

$$\begin{aligned}
 BW &= K + (Hg - C)(40) \pm 15 \\
 &= 1000 + (73 \frac{3}{4} - 70)(40) \\
 &= 1000 + (3 \frac{3}{4} \times 40) \\
 &= 1000 + 150 \\
 &= 1150 \text{ pounds}
 \end{aligned}$$

Note: ± 15 pounds according to animal's condition.

It will be shown below that this formula is dependable and therefore, along with a metal tape, is a satisfactory substitute for stock scales. It requires the use of only 12 different figures, all of which can be readily committed to memory in a logical sequence. It is practical in that it can be readily understood by farmers and its accuracy compares favorably with the U.S.D.A. standards, as shown in Table X. A total of 88 weights were collected from dry cows and from cows not too far advanced in lactation and gestation so as to be widely fluctuating in weight. The formula accuracy varied from 92.5 percent to 99.6 percent with an average accuracy of 97.3 percent on 88 weights. There was an average value of a ± 28.6 pounds on the animals recorded in Table X. Such an experimental error compares favorably with results of other authorities (10), (12) and (13) discussed earlier in this thesis.

There will be exceptions to most standards, especially those which are designed to estimate the live weight of a dairy cow. Reference is made to Design Volunteer Cowslip Fancy, a Jersey cow owned by the Knoxville Station. This cow was classified excellent in June 1947. Prior to calving, her weight was 861 pounds. At this time she was within 1 pound of the results obtained by the use of the formula suggested herein. After calving, her weight dropped to 739

TABLE IX

BASIC VALUES FOR BODY WEIGHT

AT VARIOUS HEART-GIRTHS

Heart-girth measurements (inches)	Body weight Maddux (lbs.)	Body weight Kendricks (lbs.)
C	K	
65	800	800
70	1000	987
75	1200	1197
80	1400	1423
85	1600	1657

pounds with a heart-girth measurement of 66 inches. By the suggested formula this animal was 101 pounds light. There is another point of view which one can take on this cow in relation to her size. She does have an unusually large heart-girth for her body weight. This is a highly desirable characteristic in relation to body capacity and potential milk production.

U. T. Faithful Dorothy had an average weight of 1233.12 pounds on 24 different weighings, and an average heart-girth of 77.5 inches. By the proposed formula her weight should be 1300 pounds. This is another exception to the rule where the cow has ample weight and also a very good heart-girth measurement.

TABLE X

COMPARATIVE ACCURACY OF PROPOSED FORMULA

Name of cow	Number samples taken	Av. heart girth (inches)	Av. actual weight (lbs.)	Wt. derived by formula	Weight variation (lbs.)	Formula accuracy (percent)
Norma	3	64.25	773	770	- 3	99.6
Phoebe	14	66.60	800	864	+ 64	92.5
Peeress	10	70.70	993	1028	+ 35	96.6
Peggy	4	69.60	1007	984	- 23	97.7
Dorothy	14	76.70	1227	1268	+ 41	97.4
Sunshine	5	75.30	1201	1212	+ 11	99.1
Amy	10	67.90	949	916	- 33	96.5
Matilda	9	67.25	894	890	- 4	99.5
Lovenia	7	75.90	1268	1236	- 32	98.2
Violet	5	69.70	1015	988	- 27	97.3
Roxy	5	72.30	1053	1092	+ 39	96.4
Total	88					
Average					28.4	97.3

CHAPTER V

SUMMARY

1. A study was made of the factors affecting the weights of dairy cattle in the Knoxville, Columbia and Jackson Experiment Stations. All the Stations maintain Jersey herds and a Holstein herd is kept at the Knoxville Station.

2. Nine Jersey cows averaged 1003.1 pounds in weight before calving, 889 pounds after calving and losing 114.1 pounds at calving. The calves averaged 60.5 pounds and the "remaining losses" amounted to 53.6 pounds. The average loss at calving in terms of after-calving weight was 12.95 percent.

3. The average calving loss in 163 parturitions for first- and second-calf heifers and mature cows was 98.3 pounds, 116.4 pounds and 109.5 pounds, respectively.

4. The average parturition loss from the Knoxville, Columbia and Jackson Stations for 209 parturitions was 109.92 pounds.

5. Seven Holstein cows averaged 1450.8 pounds prior to calving, 1233.4 pounds after calving and had a total loss of 217.4 pounds at parturition. The calves averaged 91.86 pounds and "other losses" amounted to 125.57 pounds. On the basis of after-calving weight, the average loss for these Holstein females was 17.6 percent. Three first-calf heifers lost an average of 146 pounds at parturition.

6. Heart-girth losses at parturition ranged from 3 inches to 7 inches for Jersey and Holstein cows. The widest decline occurred for the two breeds 24.97 days after calving and the average variation was 5.21 inches.

7. The average lactating cow in the Columbia and Jackson herds gained some weight in each month of the year except March and July. Calving losses were not included in these data.

8. A study of 6 lactations each of cow H-8 and cow W-43 of the West Tennessee Experiment Station showed a 30-pound total gain in weight during the first five months of lactation, including two months of gestation. The last seven months of lactation showed a sharp decline in milk production and a total gain of 107 pounds during the last part of gestation. During the last five months of gestation the cows averaged 92.1 percent of the total gained from calving to the next parturition. The total average calving loss was 131 pounds. There was a sharp decline in milk production at the end of the fifth month and a trend upward in gaining weight at the same point. A gain of 1/8 of the conception weight was made during pregnancy.

9. Fifteen Jersey and Holstein cows showed a heart-girth decrease of 5.3 inches with an average loss in weight of 210.1 pounds during the calving period and the first month thereafter. The average weight loss per inch of decline in heart-girth measurements amounted to 39.64 inches.

10. The following formula is suggested for rapid live weight determination in dairy cows:

$$BW = K + (Hg - C)(40) \pm 15.$$

11. The following values are applicable to the formula shown in paragraph 10 above:

<u>C</u> <u>Heart-girth measurements</u>	<u>K</u> <u>Body-weight</u>
65 inches	800 pounds
70 inches	1000 pounds
75 inches	1200 pounds
80 inches	1400 pounds
85 inches	1600 pounds

12. The formula suggested above shows an accuracy of 97.3 percent with an average of 28.6 pounds variation on 11 cows, involving 88 separate determinations.

13. Feed was kept a constant factor in weight variations at Knoxville.

14. Temperature has an indirect effect upon the weights of dairy cattle. Since all cattle were exposed to identical weather conditions in this investigation, the temperature and humidity were considered as constant factors at Knoxville.

15. Cows 303 and 245 showed a weight loss of 146.4 pounds, due to sickness alone at calving.

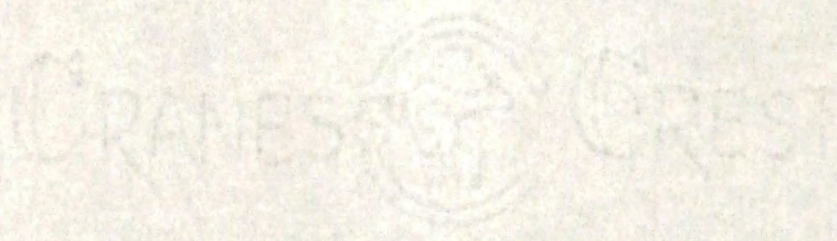
CHAPTER VI

CONCLUSIONS

1. The loss in weight of the Jersey cows studied at calving time was 12.95 percent of their weight after calving.
2. The loss in weight of the Holstein cows studied at calving time was 17.6 percent of their weight after calving.
3. Heart-girth measurements apparently vary directly with body weight and the weight per inch of heart-girth variation is near 40 pounds for measurements ranging from 65 inches to 85 inches.
4. There is a tendency for Jersey cows to lose weight in February, March and July under Middle Tennessee and West Tennessee conditions.
5. Parturition, lactation and gestation are the major factors controlling the weight of a dairy cow which is in normal condition, providing the feeding requirements are satisfied.
6. The approximate weight of a dairy cow may be rapidly determined in the field by the use of the following formula:
$$BW = K + (Hg - C)(40) \pm 15$$
7. Sickness may cause extremely heavy weight losses in dairy cows.

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