May 20, 1948

To the Committee on Graduate Study:

I am submitting to you a thesis written by James T. Miles entitled "Raising Dairy Calves With and Without Colostrum." I recommend that it be accepted for ten 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:

E. Winters

S. A. Hinton

Accepted for the Committee

E. A. Watters

Dean of the Graduate School

RAISING DAIRY CALVES WITH AND WITHOUT COLOSTRUM

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

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by

James T. Miles

June 1948

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-J.T.M.

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CHAPTER I

INTRODUCTION

The object of this study was to determine the efficiency of milk, supplemented with a laxative and different vitamins, as a substitute for colostrum in raising dairy calves from birth.

Many valuable brood cows, though still reproducing normally, may fail to produce colostrum suitable for calf feeding due to infected udders or advancing age. This frequently results in the loss of valuable calves and in good brood cows being disposed of before their usefulness is completed.

The practice of milking high producing cows before parturition has increased in recent years. Hansen et al (9), Ragsdale et al (27), and Woodman and Hammond (40) have shown that when cows are milked as much as ten to fifteen days before parturition the secretion will be milk instead of colostrum at parturition.

CHAPTER II

REVIEW OF RELATED SUBJECTS

Colostrum is the fluid present in the normal mammary gland at parturition (37). Colostrum and milk vary sufficiently in composition that they are considered as different substances.

One of the most significant differences in colostrum and milk is in their total solid contents. Jacobsen and Wallis (15) found by analysing 894 samples of colostrum taken on the day of parturition that the total solids averaged 20.2 per cent compared to 12.0 per cent on samples taken from the same cows fifteen days later. An average of the analyses of colostrum made by twenty-five investigators, working before 1926, published by Garrett and Overman (8), gives an average of 24.5 per cent total solids for cows' colostrum on the day of parturition. There is a wide difference in the total solids content of the colostrum from different cows, as shown by the maximum of 38.4 per cent total solids and the minimum of 13.72 per cent total solids found by these same twenty-five investigators. Woodman and Hammond (40) obtained values of 40.0 per cent total solids in the mammary fluid of a heifer in the last month of her first pregnancy. Eugling (6) reports 26.93 per cent, and Garrett and Overman (8) report 26.40 per cent total solids during the first day after parturition.

The high total solids content of colostrum is due largely to its high percentage of proteins. Engel and Schlag (5) found 17.57 per cent protein in colostrum immediately after parturition. Garrett and Overman

(8) report 13.97 per cent protein in the colostrum of a Holstein cow and 14.70 per cent protein in the colostrum of an Ayrshire cow as compared to 2.92 per cent protein and 3.17 per cent protein respectively on the same cows ten days later. Woodman and Hammond (40) found 35.0 per cent globulin in the mammary secretion of a heifer during the last month of pregnancy. The findings of twenty-five investigators published by Garrett and Overman (8) give an average value of 16.76 per cent protein on the day of parturition and 6.16 per cent protein four days later.

Wells and Osborne (39) demonstrated by the use of the anaphylaxis test that there are four distinct types of protein in milk. They also showed that the globulin of milk was identical with serum globulin while the other milk proteins were different from the proteins of the blood. Most investigators quote total protein. Some of the earlier, as Engel and Schlag (5), give albumin and globulin combined under a heading of albumin. Harding (12) reports that the globulin content of colostrum may be as high as 13.0 per cent. Ragsdale et al (27) give a globulin value of 18.0 per cent in colostrum. One of the highest reports on the per cent of globulin in colostrum was 35 per cent by Woodman and Hammond (40) in a heifer less than one month before parturition. The casein and albumin content of colostrum is higher than in milk but the difference is not as significant as the difference in the globulin content of the two fluids (40).

Framulener (7) working with goat and sheep erythrocytes established the fact that antibodies were present in colostrum. He found a

relationship between the antibody and the globulin content of colostrum. Reymann (28) immunized pregnant goats against coli and typhoid organisms. He then determined the titer of agglutinins in the blood of the dam. After parturition he studied the agglutinin titer of the colostrum. He found that the colostrum titer for these agglutinins was high, even exceeding the titer of the blood serum of the dam in some instances. Others, Mason et al (17), Nelson (19), and Sato et al (29), working with coli, typhoid, diptheria and other organisms have shown that the antibodies found in a cow's blood serum are found in her colostrum.

The separate works of Howe (13) and Nelson (19) show that there is a relationship between the globulin fraction and the antibody titer of colostrum. Both of these investigators used the chemical analysis of the blood of a cow, of her colostrum, and the blood of her calf, both before ingestion of colostrum and after ingestion of colostrum, to show the transmission to the calf of coli agglutinins and euglobulin and pseudoglobulin I fractions by way of the colostrum.

Investigators disagree on the amount of fat present in colostrum at parturition and throughout the colostral period. Eugling (6) gave a low percentage, 3.54, immediately after parturition with percentages up to 4.75 for the next three days, going down to an intermediate figure of 4.08 per cent at seventy-two hours after parturition. Garrett and Overman (8) report 8.45 per cent fat in colostrum of a Holstein cow at parturition and 13.02 per cent fat six hours after parturition. The fat percentage of her colostrum gradually declined to 4.33 per cent at eleven days, considered by Garrett and Overman (8) to be the end of the

colostral period. They also report on an Ayrshire cow, whose fat test was 8.46 per cent at twelve hours after parturition and gradually declined to 3.73 per cent fat at eleven days. The summary of the findings of twenty-five investigators compiled by Overman (8) give a variation of from .15 per cent fat to 9.55 per cent fat in colostrum during the day of parturition. Jacobsen and Wallis (15), from their study of colostrum samples of four breeds, found that the fat content was extremely variable for the first three days following parturition, ranging from a minimum of 1.4 per cent to a maximum of 8.5 per cent fat. They found the percentage more uniform after the first three days and that on the fifteenth day the fat percentage was 3.9 per cent. The average per cent fat of their samples for the first three days was slightly higher than the percentages on the fifteenth day.

The lactose in colostrum is of the same composition as that found in milk but it is found in smaller amounts, usually from 2 to 3 per cent at parturition, as shown by the works of Eugling (6), Engel and Schlag (5), Jacobsen and Wallis (15), and Garrett and Overman (8). The percentage of lactose in colostrum rises gradually as the percentage of most of the other solid constituents go down.

Colostrum contains a much higher proportion of minerals than does milk, according to Eugling (6), Woodman and Hammond (40), Engel and Schlag (5), Garrett and Overman (8), and Ragsdale et al (27). Garrett and Overman (8) report that the total ash is high in colostrum at parturition and that it declines steadily until the secretion reaches the composition of milk. Jacobsen and Wallis (15) found a high total

ash content of colostrum on the first day after parturition with a sharp drop on the third day, followed by a gradual decline to normal by the fifteenth day. Their findings were: 900 milligrams of ash per 100 milliliters of colostrum at parturition, 775 milligrams on the third day and 675 milligrams on the fifteenth day. Garrett and Overman (8) found high levels of calcium, phosphorous, magnesium, and sodium with a gradual decline of these accompanied by a rise in potassium as colostrum changed to milk. Their analyses are shown by the following summary:

	Per Cent At Parturition	Per Cent Ten Days Later
Calcium	.231	.125
Magnesium	.035	.011
Phosphorous	.213	.111
Sodium	.077	.041
Potassium	.131	.152

Jacobsen and Wallis (15) draw a direct correlation between the percentages of calcium and phosphorous and the percentage of total ash in colostrum. Davies (2) reports an iron content of 25 parts per million in colostrum compared to 2.5 parts per million in milk.

In more recent years the increasing knowledge of vitamins and vitamin chemistry has placed much emphasis on the vitamin content of colostrum and its effect on the calf. Stewart and McCollum (35) assayed colostrum for vitamin A from one hundred Ayrshire cows on fourteen farms during the stall fed period for the first seven days after parturition. They obtained vitamin A contents ranging from 35 I. U. (International Unit) to 1181 I. U. per 100 milliliters of colostrum, with an arithmetical mean of 392 I. U. for the seven day colostral period. Eaton et al (3) collected colostrum from several cows on winter rations. They pooled

this colostrum, mixed it thoroughly and then determined the carotene and vitamin A content. It contained 254 micrograms of carotene and 1,143 micrograms of vitamin A per pound of colostrum. They then compared this to a composite sample of herd milk from the same herd receiving the same feed and management. The herd milk contained 48 micrograms of carotene and 95 micrograms of vitamin A per pound of milk. Hansen et al (10) give a value of 6,350 I. U. of carotene and 5,260 I. U. of vitamin A per pound of colostrum as compared with 172 I. U. of carotene and 314 I. U. of vitamin A per pound for herd milk. They emphasized that cows of a uniform age that had received identical rations varied widely in the vitamin A content of their colostral milks.

Pearson and Darnell (22) determined the amount of four of the B complex vitamins in cows' colostrum and milk. Their results are summarized below.

	Colostrum Micrograms Per Milliliter		Milk Micrograms Per Milliliter	
	Mean	S. D.*	Mean	S. D.*
Riboflavin	6.10	1.85	1.77	.31
Nicotinic Acid	.96	.29	.91	.16
Pantothenic Acid	2.24	.87	3.67	.57
Thiamine	.62	.06	.38	.05

Waugh et al (38) report levels of choline in colostrum of .69 micrograms per milliliter as compared with .14 micrograms per milliliter at the end of the colostral period.

Eaton et al (4) report 23 I. U. of vitamin D per pound from their

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*S. D. is the abbreviation for Standard Deviation.

pooled colostrum and 10 I. U. of vitamin D per pound from their composite milk samples.

Parrish et al (20) report average levels of tocopherols in the first colostrum seven to twelve times as high as that in milk from the same cows on the eighth day.

Framulener (7) demonstrated that colostrum is the chief agent in bringing about the passive immunization of sucklings and that they rapidly gain a well maintained antibody content in their blood when fed colostrum. Smith and Little (30) found that calves fed colostrum survived more frequently than those deprived of it. Coli organisms were found all through the bodies of calves that died as a result of not receiving colostrum. Working with bacillus abortus they showed that agglutinins not present in the calf's blood appeared quickly after ingestion of colostrum. Nelson (19) established a bacteriolytic action in blood serum which appears in some way to protect newborn calves against coli infections. He further demonstrated that the newborn calf did not have definite agglutinins for coli organisms before receiving colostrum but that these appear in the blood shortly after the ingestion of colostrum. He also concluded that the calf that receives colostrum is better fortified against an invasion of coli due to the combined effect of the natural bacteriolytic action and of the agglutinins passively transferred to its blood stream from the colostrum. Nelson's work, considered with the euglobulin and pseudo-globulin levels of the blood of a newborn calf before and after receiving colostrum, as established by Howe (14), bears out the earlier conclusion of Crowther and Raistrick (1) that the antibody function and globulin

content of colostrum are closely related.

Much of the more recent work has been devoted to the function of the vitamins found in colostrum. Moore and Berry (18) found that the vitamin A content of the blood plasma of a newborn calf increased five-fold after an intake of colostrum. They also found three calves whose blood plasma vitamin A content did not rise after ingestion of colostrum. These calves died of infections as did two of three calves fed milk instead of colostrum. The calves fed milk showed a very small increase in the vitamin A level of the blood.

Spielman et al (33), in studying carotene utilization in the newborn calf, fed eleven newborn calves a skimmilk ration with added carotene. In order to minimize the possibility of a shortage of other vitamins each calf received daily a capsule containing 1000 I. U. of vitamin D, 250 milligrams of ascorbic acid, 50 milligrams alphatocopherol, 10 milligrams each of thiamine, riboflavin and pyridoxine, 100 milligrams of niacin, and 50 milligrams of choline chloride. Each calf received a transfusion of about 500 milligrams of its dams blood shortly after birth. Ten of the eleven calves failed to gain weight and died at about seven days of age regardless of the source of carotene. Insignificant amounts of carotene and vitamin A were found in the livers on post-mortem examination. A later group of calves received the same ration with 4 to 8 grams of sulfathalidine daily instead of the infusion of the dams blood. The calves were raised to sixty days of age and scours were prevented or controlled in most cases. They found that when scours were controlled, newborn calves were able to utilize the carotene in a commercial concen-

trate at a rate sufficient to provide for satisfactory growth and some storage of vitamin A in the liver.

Hansen et al (9) studied the effect of vitamin supplements upon survival of newborn calves. The calves were fed from birth on a basal ration of skimmilk supplemented with ascorbic acid and different amounts of vitamin A. Each calf was fed skimmilk at the rate of twelve pounds per hundred pounds body weight and was given 250 milligrams of ascorbic acid daily. The ascorbic acid was given orally. The calves were divided into two groups: One group received 10,000 I. U. of vitamin A daily in gelatin capsules, the other group 25,000 I. U. of vitamin A. Vitamin A levels were determined on blood plasma of newborn calves and again after they had ingested colostrum. They found values of 4 micrograms per 100 milliliters of blood plasma at birth; after ingestion of colostrum the vitamin A levels rose to 10 micrograms per 100 milliliters. They then compared the blood plasma vitamin A levels of the two groups of vitamin supplement fed calves with the blood plasma vitamin A levels in the colostrum fed calves. The vitamin A levels of the group fed 10,000 I. U. did not rise to the 10 microgram level in thirty-six hours while those fed 25,000 I. U. of vitamin A per day produced blood plasma vitamin A levels comparable to calves fed colostrum.

Calves fed the basal ration of skimmilk normally showed a looseness of the bowels regardless of the vitamin supplement given. Calves that developed fevers of 104° F. or above were treated with 2 to 4 grams of sulfathiazole for one day with smaller doses thereafter as the condition of the calf indicated.

Of the group of calves receiving 10,000 I. U. vitamin A, 89 per cent had scours and 44 per cent survived. Only 60 per cent of the group given 25,000 I. U. vitamin A had scours and 75 per cent survived.

Hansen et al (9) also report that neither nicotinic acid or its amide given orally at the rate of 50 milligrams daily increased the survival rate of calves fed adequate amounts of vitamin A. They concluded that blood plasma vitamin A should reach a level of 9 or 10 micrograms per 100 milliliters of blood during the first two days to provide a favorable chance of survival.

Sutton and Kaiser (36) extended the colostrum feeding period of calves from four to seven days to determine the effect on amounts of carotene, vitamin A, and ascorbic acid in the blood plasma, and on the health and growth of the calf. They found much higher vitamin A levels at seven days of age on the group fed colostrum for seven days than on the group fed colostrum for four days. The difference in vitamin A levels, though still in favor of the seven-day group, was much less at fourteen days. The rate of gain was about twice as much at seven days on the group fed colostrum but the difference in rate of gain was not significant at fourteen days of age.

Lundquist and Phillips (16) report blood plasma vitamin A levels on newborn calves before and after ingestion of colostrum substantially the same as those reported by Hansen et al (11).

They fed calves on a basal ration of skimmilk, grain, and hay with different vitamin supplements. Of three calves receiving the basal ration plus vitamin A, two died of peritonitis. They were able to

eliminate losses of calves from peritonitis by adding ascorbic acid at the rate of .25 to .50 grams daily for varying periods up to twenty days. They found that ascorbic acid given orally affected the vitamin C blood level for only ten or twelve days after birth. Their diet of skimmilk with vitamins A, C, and D and irradiated ergosterol added supported life but did not control scours. The addition of nicotinic acid controlled scours while the addition of pantothenic acid had no favorable results. They were able to raise Holstein calves on skimmilk with supplements of vitamins A, C, D, and nicotinic acid, but growth was not normal. They were unable to raise Jersey and Guernsey calves consistently on the same schedule.

CHAPTER III

EXPERIMENTAL PROCEDURE

This study to determine the efficiency of milk, supplemented with a laxative and different vitamins as a substitute for colostrum in raising dairy calves from birth was conducted at the Tennessee Experiment Station at Knoxville, and was started in November, 1946. Jersey and Holstein bull calves born in the University herd were divided into four groups at birth.

Group I

The calves in this group were allowed to remain with their dams for three days following birth. On the fourth day they were separated from their dam and fed milk at the rate of one pound milk for each ten pounds of body weight. The dam's milk was fed until the calf was seven days old, Holstein milk was fed after seven days. Milk was fed at the rate of one pound milk to ten pounds body weight until Jersey calves were consuming seven pounds milk daily and Holstein calves ten pounds milk daily. When this level of milk feeding was reached it was continued until the calf was 120 days old. As soon as the calves would eat grain they were fed as much of a mixture of 20 pounds yellow corn, 20 pounds oats, 15 pounds wheat bran, 1 pound bone meal and 1/2 pound salt as they would consume until they were cleaning up 4 pounds of this mixture daily. Grain was fed at this level until the calf was 120 days of age. Good quality hay was fed ad. lib. during the complete period. When the

weather was suitable the calves from all four groups were put in a small grass lot for a few hours each day.

Group II

The calves in this group were separated from their dams at birth and were given 32 milliliters of medium weight mineral oil. Initially the mineral oil was given as a drench; after some difficulty was encountered with strangling, the mineral oil was mixed with the first feed of milk. Holstein milk was fed at the rate of one pound milk to each ten pounds of body weight for the first seven days. Each calf was given 500,000 I. U. of vitamin A on the day of birth and 25,000 I. U. for the next six days. The vitamin A was given orally as a gelatin capsule. After the calves were seven days old they received the same feed and care as the calves in Group I.

Group III

The seven calves in Group III were given three .5 gram tablets of sulfathiazole per day for the first seven days. With the exception of the added sulfathiazole they were fed and handled the same as the calves in Group II.

Group IV

The calves in Group IV were separated from their dams at birth. They were given 32 milliliters of medium weight mineral oil mixed in

from 3 to 5 pounds of Holstein milk between 2 and 6 hours after birth. Holstein milk was fed at the rate of one pound milk per ten pounds of body weight for the first seven days. Each calf was given 500,000 I. U. of vitamin A the day of birth and 25,000 I. U. for the next six days. The vitamin A was given orally as gelatin capsules. Each calf was given a gelatin capsule containing 20 milligrams thiamine, 40 milligrams riboflavin, 40 milligrams niacin, 120 milligrams pantothenic acid, 4 milligrams pyridoxine, 20 milligrams folic acid and 4000 I.U. of vitamin D each day until he was seven days of age. After the first seven days, the calves in Group IV received the same feed and care as the calves in Group I.

Treatment of Scours

Scours and other physiological disorders were treated by Dr. Dennis Sikes, the University veterinarian. Two methods of treatment were used. When symptoms indicated an intestinal infection, sulfaquanidine was given at the rate of 1 grain per pound body weight each day, divided into two or three doses. When a respiratory or generalized infection was indicated with an intestinal infection, Disulfalac was administered at the rate of 1 milliliter per pound of body weight in addition to the sulfaquanidine treatment.

Records Kept

The following records were kept:

1. Breed of calves
2. Birth weights of calves
3. Daily weights of calves under one month of age
4. Weekly weights of calves over one month of age
5. Weekly skeleton measurements (height at withers and heart girth)
6. Milk fed daily
7. Grain consumed daily
8. Hay consumed daily

CHAPTER IV

RESULTS

The number of calves included in each group and their mortality is shown in Table I. Groups I and IV had a survival rate of 100 per cent. All of the Jerseys in Group II died and all the Holstein calves lived, giving a 50 per cent survival rate for the Group. One of the three Holsteins and one of the four Jerseys in Group III died, giving a survival rate of 71 per cent for this group.

Only one of the fourteen Holsteins included in the trial died, a survival rate of 92.8 per cent for the Holstein calves in all groups. Four of the fifteen Jersey calves died, giving a survival rate of 73.3 per cent for all the Jerseys included in the trial.

Incidence of Scours

The incidence and duration of scours is shown in Table II. This table covers the period from birth until the calves are twenty days of age. Calf 536 is the only calf scouring noticeably after the twentieth day. Calf T255 died of pneumonia on the twenty-eighth day but showed no visible sign of scours at this time.

Two of the six calves (33.3 per cent) which received their dam's milk for the first seven days showed definite signs of diarrhea.

Five of the six calves (83.3 per cent) in Group II had scours. All five of these calves started scouring on the third day; one died on the fourth day, another on the fifth day, and a third calf, T255, died

TABLE I

MORTALITY OF CALVES

Group	Number Holstein Calves	Number Jersey Calves	Total Number Calves	Number Holstein Calves Died	Number Jersey Calves Died	Total Calves Died
I	3	3	6	0	0	0
II	3	3	6	0	3	3
III	3	4	7	1	1	2
IV	5	5	10	0	0	0

TABLE II

THE INCIDENCE AND DURATION OF SCOURS

Calf No.	Breed	Group	Day of Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
509	H	1																				
511	H	1																				
512	H	1																				
T224	J	1							+	+												
T243	J	1																				
T249	J	1									+	+	+									
532	H	2			+	+										+	+	+				
534	H	2																				
536*	H	2			+	+	+															
T231	J	2			+	+	Died															
T232	J	2			+	Died																
T255**	J	2			+	+																
521	H	3																				
525	H	3																	+	+	+	+
526	H	3			+	+	+	Died														
T237	J	3																	+	+	+	+
T242	J	3								-	-	-	-	-	-	-	-	-				
T244	J	3																				
T245	J	3				+	+	+	Died													
527	H	4															+	+	+	+		
528	H	4																				
529	H	4																				
533	H	4										+	+	+								
535	H	4					+	+	+	+												
T246	J	4																				
T247	J	4																				
T251	J	4					+	+	+	+		-	-	-	-	-	-					
T252	J	4												+	+	+	+	+				
T253	J	4			+	+	+															

\+ Indicates scours. -Indicates high temperature and respiratory disturbances without scours.

* 536 had a reoccurrence of scours on 31st day lasting through 34th day.

**T255 died on 28th day results of pneumonia which set in on 20th day.

of pneumonia on the twenty-eighth day. The two other calves survived but one had a reoccurrence of diarrhea on the fourteenth day and the other on the thirty-first day.

In Group III four of the seven calves (57.1 per cent) had diarrhea. One other calf in Group III had a rather severe respiratory disturbance but showed no symptoms of diarrhea. He responded to treatment and apparently recovered completely. The two calves in this group which had scours at an early age died; the other two calves which had diarrhea after they were fifteen days of age responded to treatment rapidly.

Sixty per cent of the calves in Group IV had scours but all responded to treatment. Four of these ten calves had very light cases of diarrhea which had very little effect on their growth and general condition.

Six of the fourteen Holstein calves (42.8 per cent) had diarrhea and only one calf failed to respond to treatment. Ten of the fifteen Jersey calves (66.7 per cent) had scours. Four of these ten calves failed to respond to treatment and died.

Growth

Weight

The individual weights of each calf at birth, 60 days and 120 days of age are shown in Table III. The weekly weights of each calf are shown by group and breed compared to the breed average of the check group, Group I, in Figures 3 - 9.

TABLE III

CALF WEIGHTS AT 60 AND 120 DAYS OF AGE

Calf No.	Breed	Birth Weight (lbs.)	Weight at 60 Days (lbs.)	Weight at 120 Days (lbs.)	Gain Per Calf Per Day (lbs.)
			Group I		
509	H	76	131	235	1.33
511	H	88	127	210	1.02
512	H	87	140	245	1.33
T224	J	50	90	181	1.09
T243	J	55	93	178	1.03
T249	J	39	87	168	1.08
			Group II		
532	H	78	133	*	.92
534	H	92	140	*	.80
536	H	91	155	*	1.07
T231	J	52	**		
T232	J	69	**		
T255	J	55	**		
			Group III		
521	H	102	154	251	1.24
525	H	92	148	276	1.53
526	H	57	**		
T237	J	70	91	161	.76
T242	J	55	77	133	.65
T244	J	50	90	141	.76
T245	J	65	**		
			Group IV		
527	H	90	153	277	1.56
528	H	85	162	295	1.75
529	H	98	161	309	1.76
533	H	83	128	*	.75
535	H	92	145	*	.88
T246	J	53	85	185	1.10
T247	J	46	91	177	1.09
T251	J	60	84	135	.63
T252	J	45	62	*	.28
T253	J	48	55	*	.12

* Calves are not 120 days of age at this writing.
** Calves died before reaching 60 days of age.

TABLE IV

GROUP AVERAGE WEIGHT AND AVERAGE GAIN IN WEIGHT

Group	Breed	Number Calves	Birth Weight Mean (lbs.)	Birth Weight S. D. (lbs.)	Weight at End of Period Mean (lbs.)	Weight at End of Period S. D. (lbs.)	Gain Per Calf Per Day Mean (lbs.)	Gain Per Calf Per Day S. D. (lbs.)
			At 60 Days of Age					
I	H	3	84	6.7	133	6.7	.82	.13
II	H	3	87	7.8	143	11.2	.93	.14
III	H	2	97	7.1	151	4.2	.90	.04
IV	H	5	90	6.0	150	14.0	1.00	.20
I	J	3	48	8.0	90	3.0	.70	.09
III	J	3	58	10.4	86	7.8	.46	.18
IV	J	5	50	6.2	75	15.9	.42	.24
			At 120 Days of Age					
I	H	3	84	6.7	230	18.0	1.23	.18
III	H	2	97	7.1	264	18.0	1.39	.22
IV	H	3	91	6.6	294	16.0	1.69	.11
I	J	3	48	8.0	176	6.8	1.07	.03
III	J	3	58	10.4	145	14.5	.72	.06
IV	J	3	53	7.0	166	26.7	.94	.27

Table IV shows the average weight and the average gain in weight per calf per day for each group by breed at 60 and 120 days of age. The average weekly weights of each group are shown by breed in Figures 1 and 2.

The Holstein calves in Group I gained an average of .82 ± .13* pounds daily for the first 60 days and 1.23 ± .18 pounds per day for 120 days. The Holstein calves in Group II gained .93 ± .14 pounds daily for the first 60 days. None of the calves in this group have reached 120 days of age. The Holstein calves in Group IV gained 1.00 ± .20 pounds per day for 60 days and 1.69 ± .11 pounds per day for 120 days.

The Jersey calves in Group I gained an average of .70 ± .09 pounds per day for 60 days and 1.07 ± .03 pounds per day for 120 days. The Jersey calves in Group III gained an average of .46 ± .18 pounds per day for 60 days and .72 ± .06 pounds per day for 120 days. The Jersey calves in Group IV gained .42 ± .24 pounds for the first 60 days and .94 ± .14 pounds for 120 days. No Jersey calves in Group II lived to be 60 days of age.

Height

The height at birth, 60 days of age, 120 days of age, and the gain in height per day are shown for each calf in Table V.

Table VI shows the average height and the average gain in height per calf per day for each group by breed at 60 and 120 days of age.

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* When ± is used, the figure following is standard deviation.

TABLE V

HEIGHT AT WITHERS OF CALVES AT 60 AND 120 DAYS OF AGE

Calf No.	Breed	Height at Birth (inches)	Height at 60 Days (inches)	Height at 120 Days (inches)	Gain in Height Per Day (inches)
			Group I		
509	H	29.50	32.00	36.75	.060
511	H	29.50	32.00	35.75	.052
512	H	29.50	32.00	36.25	.056
T224	J	26.00	28.50	32.50	.054
T243	J	25.00	28.50	32.75	.065
T249	J	23.50	28.00	32.50	.075
			Group II		
532	H	27.50	31.50	*	.067
534	H	30.00	33.00	*	.050
536	H	30.50	33.25	*	.046
			Group III		
521	H	29.50	33.25	36.75	.066
525	H	29.00	32.50	38.00	.075
T237	J	27.00	28.75	32.50	.046
T242	J	26.00	28.50	32.00	.050
T244	J	26.00	29.00	33.00	.058
			Group IV		
527	H	29.50	33.00	37.00	.063
528	H	30.00	33.50	38.50	.071
529	H	29.00	32.75	38.00	.075
533	H	28.50	32.00	*	.058
535	H	30.00	33.25	*	.054
T246	J	27.00	29.75	33.50	.054
T247	J	25.50	28.75	33.50	.067
T251	J	27.00	28.75	31.25	.035
T252	J	25.00	26.50	*	.025
T253	J	25.75	26.50	*	.013

* Calves are not 120 days of age at this writing.

TABLE VI

GROUP AVERAGE HEIGHT AND AVERAGE GAIN IN HEIGHT

Group	Breed	Number Calves	Height at Birth (inches) Mean	S. D.	Height at End of Period (inches) Mean	S. D.	Gain Per Calf Per Day (inches) Mean	S. D.
			At 60 Days of Age					
I	H	3	29.50	0	32.00	0	.042	0
II	H	3	29.33	1.61	32.58	.95	.054	.014
III	H	2	29.25	.35	32.88	.53	.061	.004
IV	H	5	29.40	.67	32.90	.58	.058	.003
I	J	3	24.83	1.26	28.33	.29	.058	.017
III	J	3	26.33	.58	28.75	.25	.040	.011
IV	J	5	26.05	.91	28.05	1.47	.033	.016
			At 120 Days of Age					
I	H	3	29.50	0	36.25	.50	.056	.004
III	H	2	29.25	.35	37.38	.88	.071	.006
IV	H	3	29.50	.50	37.83	.76	.070	.006
I	J	3	24.83	1.26	32.58	.14	.065	.011
III	J	3	26.33	.58	32.50	.50	.051	.006
IV	J	3	26.50	.86	32.75	1.30	.052	.016

Heart Girth

The heart girth at birth, 60 days of age, 120 days of age and the gain in heart girth per day are shown for each calf in Table VII.

Table VIII shows the average heart girth and the average gain in heart girth per calf per day for each group by breed at 60 and 120 days of age.

Feed Consumption

The total milk, grain and hay consumed by each group of calves is shown in Table IX. Since individual pens were not available for this trial, grain and hay consumption figures are available only by groups. Table IX shows the amount of milk, grain, and hay consumed for each pound of gain in each group. The weights of milk for Groups II, III, and IV are from birth but the weights of milk for Group I start on the fourth day as no accurate weights of milk consumed were available while the calf was nursing its dam.

TABLE VII

HEART GIRTH MEASUREMENTS OF CALVES AT 60 AND 120 DAYS OF AGE

Calf No.	Breed	Heart Girth at Birth (inches)	Heart Girth at 60 Days (inches)	Heart Girth at 120 Days (inches)	Gain in Heart Girth Per Day (inches)
			Group I		
509	H	30.00	36.00	42.00	.100
511	H	30.00	34.50	41.00	.092
512	H	32.00	35.00	42.00	.083
T224	J	25.00	30.50	37.50	.104
T243	J	26.00	30.50	37.00	.092
T249	J	24.00	29.00	37.25	.110
			Group II		
532	H	29.50	34.00	*	.075
534	H	30.00	34.25	*	.071
536	H	30.75	35.75	*	.083
			Group III		
521	H	31.50	35.25	42.00	.088
525	H	30.00	34.00	44.00	.117
T237	J	28.00	31.00	37.00	.075
T242	J	26.00	30.50	36.00	.083
T244	J	26.00	30.75	36.00	.083
			Group IV		
527	H	29.50	36.25	44.00	.121
528	H	29.75	36.00	45.00	.127
529	H	30.50	36.00	45.00	.121
533	H	29.00	34.00	*	.083
535	H	30.00	34.50	*	.075
T246	J	26.00	30.25	37.00	.092
T247	J	24.50	31.00	38.00	.113
T251	J	26.00	28.75	34.00	.067
T252	J	25.00	27.50	*	.042
T253	J	25.75	27.00	*	.021

* Calves are not 120 days of age at this writing.

TABLE VIII

GROUP AVERAGE HEART GIRTH AND AVERAGE GAIN IN HEART GIRTH

Group	Breed	Number Calves	Heart Girth at Birth Mean (inches)	Heart Girth at Birth S. D. (inches)	Heart Girth at End of Period Mean (inches)	Heart Girth at End of Period S. D. (inches)	Gain Per Calf Per Day Mean (inches)	Gain Per Calf Per Day S. D. (inches)
			At 60 Days of Age					
I	H	3	30.67	1.16	35.17	.76	.075	.025
II	H	3	30.08	.63	34.67	.95	.076	.006
III	H	2	30.75	1.06	34.63	.88	.073	.008
IV	H	5	29.75	.56	35.35	.89	.093	.012
I	J	3	25.00	1.00	30.00	1.00	.083	.009
III	J	3	26.67	1.21	30.75	.25	.068	.016
IV	J	5	25.45	.67	28.90	1.72	.057	.033
			At 120 Days of Age					
I	H	3	30.67	1.16	41.67	.58	.092	.009
III	H	2	30.75	1.06	43.00	1.41	.103	.021
IV	H	3	29.92	.52	44.67	.58	.123	.003
I	J	3	25.00	1.00	37.25	.25	.102	.009
III	J	3	26.67	1.21	36.33	.58	.080	.005
IV	J	3	25.50	.87	36.33	2.08	.091	.023

TABLE IX

FEED CONSUMPTION

Total Feed Consumed

Group	Number Calves	Calf Days	Feed Consumed		
			Milk (lbs.)	Grain (lbs.)	Hay (lbs.)
I	6	720	5823	1100	1095
II	3	180	1788	306	199
III	5	600	4567	932	792
IV	10	960	7642	1667	1517

Feed Consumed Per Pound Gain

Group	Number Calves	Gain In Weight (lbs.)	Milk Per 1 lb. Gain (lbs.)	Grain Per 1 lb. Gain (lbs.)	Hay Per 1 lb. Gain (lbs.)
I	6	822	7.85	1.34	1.33
II	3	167	10.71	1.83	1.19
III	5	593	7.70	1.57	1.34
IV	10	1068	7.14	1.56	1.42

CHAPTER V

DISCUSSION

The death of all three Jersey calves that received whole milk with a vitamin A supplement instead of colostrum suggests, on the basis of the limited number of calves in this trial, that milk with vitamin A added is not a very satisfactory substitute for colostrum in raising Jersey calves. The difference between a 50 per cent survival rate of the six calves in Group II and the 71 per cent survival rate of the seven calves in Group III which received the same feed as Group II plus 1.5 grams of sulfathiazole daily for seven days suggests that the addition of a preventative bacterial agent increases the calf's chance of survival when the calf is not given colostrum. This agrees with the results of Spielman et al (33) on two groups of calves, one fed milk and carotene supplements with sulfathaladine and one fed milk and carotene supplements alone.

Life was supported effectively in the ten calves of Group IV, as evidenced by the 100 per cent survival rate of this group. In addition to the same amounts of Holstein milk and vitamin A fed Group II, they received 20 milligrams thiamine, 40 milligrams riboflavin, 40 milligrams niacin, 120 milligrams pantothenic acid, 4 milligrams pyridoxine, 20 milligrams folic acid and 4000 I. U. of vitamin D each day for the first seven days.

The 92.8 per cent survival rate of fourteen Holstein calves in all groups compared to 73.3 per cent survival rate of fifteen Jersey

calves indicates that Holstein calves are more hardy and have a stronger natural resistance to infections of the digestive tract. This is in agreement with the results of Lundquist and Phillips (16) who were able to raise Holstein calves on skimmilk supplemented with vitamins A, C, D, irradiated ergosterol, and nicotinic acid but were unable to raise Jersey calves consistently on the same schedule.

The groups of calves receiving supplemented milk had a higher incidence of scours than did the calves receiving colostrum for the first seven days. Spielman et al (33), Moore and Berry (10), Hansen et al (11), and Lundquist and Phillips (16) report similar results on a larger number of calves from the use of a wide variety of vitamin supplements with skimmilk.

The 57.1 per cent incidence of diarrhea in Group III and the 60 per cent incidence of diarrhea in Group IV compared with the 83.3 per cent occurrence of diarrhea in Group II suggests that either sulfathiazole or the mixture of vitamins used help control diarrhea when added to the ration of milk and vitamin A. The fact that some of the cases of diarrhea in Group III were very acute and did not respond to treatment while all the cases in Group IV did respond to treatment would denote an advantage for the vitamin mixture over sulfathiazole as a preventative for scours.

The Holstein calves at 120 days of age had gained an average of 1.23 $\pm$ .18 pounds per day for Group I, 1.39 $\pm$ .22 pounds per day for Group III, and 1.69 $\pm$ .11 pounds per day for Group IV compared to a 1.46 pounds per day average for Holstein bull calves in the Missouri

study (25). The Jersey calves in Group I had an average gain of 1.07 ± .03 pounds per day, Group III .72 ± .06 pounds per day, and Group IV had .94 ± .27 pounds per day compared to 1.03 pounds average gain per day given in the Missouri study for Jersey bull calves from birth to four months of age.

Snedecor's (32) formula for calculating the significant difference between groups, $t = \bar{X}\sqrt{N(N-1)/SX^2}$, was applied to the gains in weight per day of each group at the end of the 60 and 120 day intervals when the groups were of equal number. Then the groups were of unequal number, Snedecor's (32) formula of $t = \bar{X} / \sqrt{S^2(N_1+N_2)/N_1N_2}$ was used.

There was no significant difference at the five per cent probability level in gain in weight per day at 60 days between any group of either breed. At 120 days the gain per day of the Holstein calves in Group IV was significantly larger than that of Group I; however, there was no significant difference in gain per day between the Holstein calves in Groups I and III or between Groups III and IV. The rate of gain in weight of the Jersey calves in Group I was significantly larger than the Jersey calves in Group III. There was no significant difference in the rate of gain per day between the Jersey calves in Groups I and IV or between Groups III and IV.

Figure 1 shows that the Holstein calves in Groups I and III maintained a weight relationship throughout the period similar to that existing at birth but that the Holsteins in Group IV gained at a more rapid rate than either of the other two groups, especially after the ninth and tenth weeks. The average birth weights of the Jersey calves

in Group I was the smallest of the three groups, I, III, and IV, but the calves in this group gained at a more rapid rate throughout the trial and weighed a good deal more at 120 days of age than the calves in either of the other groups.

Snedecor's (32) formulae were applied to the gain in height per day as shown in Table VI. The gains of .061 ±.004 inches for the Holstein calves in Group III and .058 ± .003 inches for the Holstein calves in Group IV were significantly larger than the gain of .042 ± 0 inches for Group I at 60 days of age; also the gains of .071 ± .006 inches for the Holsteins in Group III and .070 ± .006 inches for the Holsteins in Group IV were significantly larger than the .056 ± .004 inches for Group I at 120 days of age. There was no significant difference between the average heights of the Jerseys in different groups at either 60 or 120 days of age.

The formulae for significant difference between means of groups were applied to the heart girth measurements in Table VIII. No significant difference was found between any two groups of either breed at 60 days of age. At 120 days of age the .123 ± .003 inches gain for Holsteins in Group IV was significantly larger than the .092 ± .009 inches gain for Group I. The .102 ± .009 inches gain for the Jerseys in Group I was significantly larger than the gain of .080 ± .005 inches in heart girth of the Jerseys in Group III. The other differences of heart girth measurements were not significant.

The Holstein calves fed Holstein milk with a mixture of vitamins for the first seven days made gains in weight, height and heart girth

significantly larger than the Holstein calves fed colostrum for the first seven days. The Jersey calves in this group made consistently smaller gains than the Jersey calves that received colostrum for the first seven days but none of the differences between the two groups of calves were significant except the difference in height at 120 days of age.

A comparison of the growth of Groups II and III with that of Group I is complicated by the death of some of the calves in Groups II and III. There was no significant difference in growth between the groups of Holstein calves except in height at withers between Groups I and III. No Jersey calves in Group II lived, the Jerseys in Group I gained at a significantly faster rate in weight and heart girth than the calves in Group III. This failure of the Jersey calves in Groups II and III to live and make normal growth agrees with the results of Lundquist and Phillips (16) and Moore and Berry (18). The survival and the incidence of scours of the ten calves in Group IV is in disagreement with the report of Lundquist and Phillips (16) that nicotinic acid or niacin will control scours. Their Holstein calves raised on a diet of skimmilk with vitamins A, C, D, irradiated ergosterol and nicotinic acid did not make normal gains. The Holstein calves in Group IV of this trial gained 1.69 pounds per day compared to 1.46 pounds per day reported as normal by Ragsdale (25). Lundquist and Phillips (16) were not able to raise Jersey calves consistently on their ration while the five Jersey calves in Group IV lived and there was no significant difference

between their rate of gain in weight and that reported as normal by Ragsdale (25).

The only wide variation between the groups in amount of feed per pound of weight gained is the larger amount of milk and grain and the smaller amount of hay per pound of gain in Group II. The gain in weight recorded in this group was made during the first two months of the calves' lives when they were more dependent on milk and concentrates than they were as they became a little older.

CHAPTER VI

SUMMARY

Eleven Holstein and twelve Jersey calves were fed milk with vitamin supplements from birth. The survival and growth of these calves were compared with that of three Holstein and three Jersey calves fed the dams' milk for the first seven days. All calves received identical treatment after reaching seven days of age.

Group I was the control group. Group II received a laxative shortly after birth, 500,000 I. U. of vitamin A the first day and 25,000 I. U. of vitamin A for the next six days. Group III received the same treatment as Group II with the addition of 1.5 grams of sulfathiazole daily for the first seven days. Group IV received the same amounts of laxative and vitamin A as Group II with the addition of 20 milligrams of thiamine, 40 milligrams of riboflavin, 40 milligrams niacin, 120 milligrams pantothenic acid, 4 milligrams pyridoxine, 20 milligrams folic acid and 4000 I. U. of vitamin D each day for the first seven days.

Thirty-three and three-tenths per cent of the calves in Group I had scours and 100 per cent survived. Eighty-three per cent of the calves in Group II scoured and only 50 per cent survived. In Group III 57.1 per cent of the calves had diarrhea and 71 per cent survived. Sixty per cent of the calves in Group IV had scours and 100 per cent survived.

The fourteen Holstein calves had a survival rate of 92.8 per cent and 42.8 per cent of them had scours. The survival rate on the fifteen Jersey calves in all four groups was only 73.3 per cent while 66.7 per cent of them had scours.

The calves in Groups II and III did not make satisfactory growth compared to the calves in Group I; the calves in Group IV did make satisfactory growth.

Observation of the limited number of calves in this trial indicates that herd milk, a laxative, and vitamin A with or without added sulfathiazole will not support life and satisfactory growth when substituted for the dam's milk from birth. The observation of Group IV suggests that when herd milk, a laxative, vitamins A and D, thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, and folic acid are substituted for the dam's milk from birth that life and satisfactory growth will be supported but that scours will not be completely controlled.

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APPENDIX

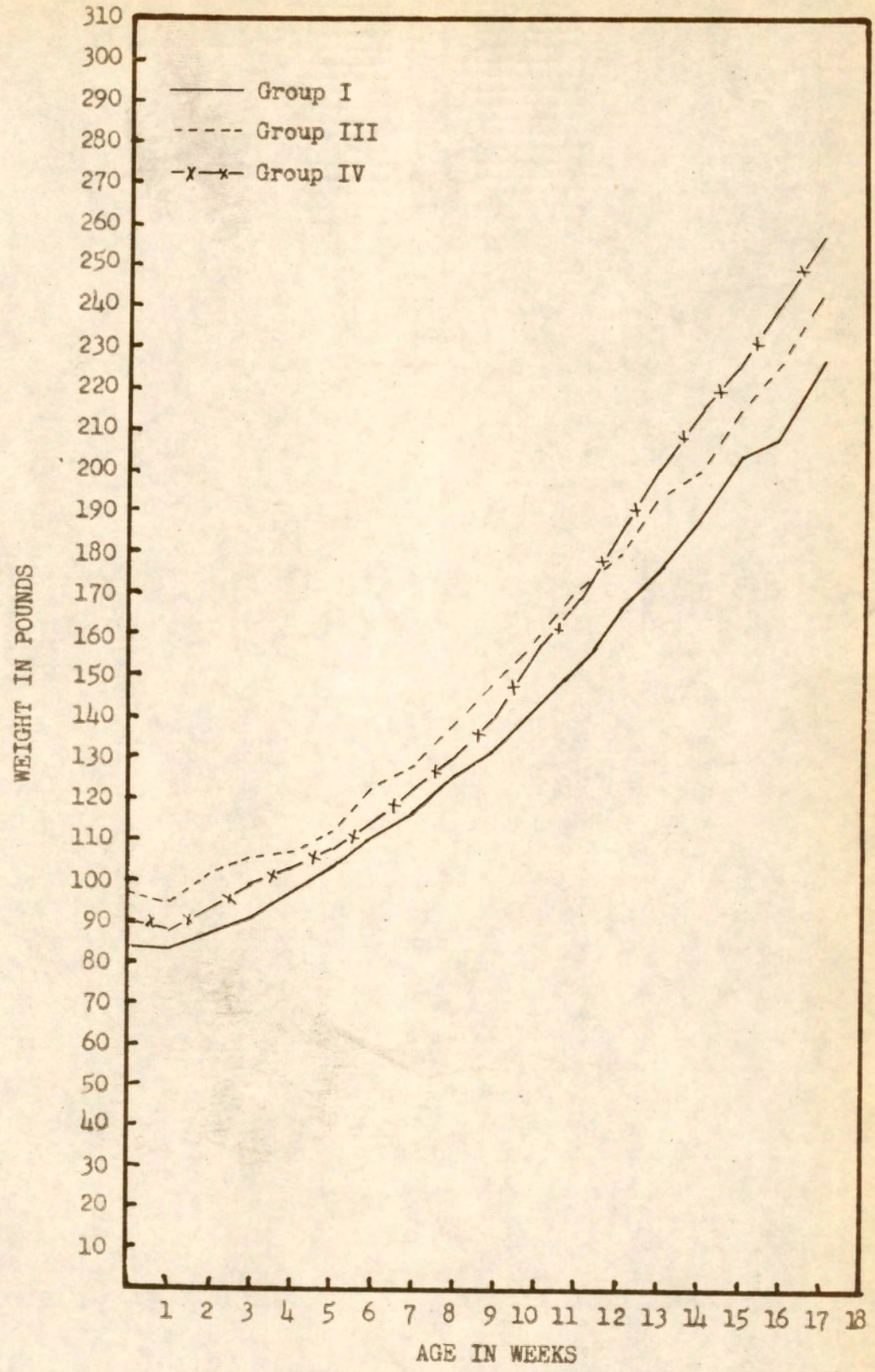

Figure 1. Average Weight of Holstein Calves.

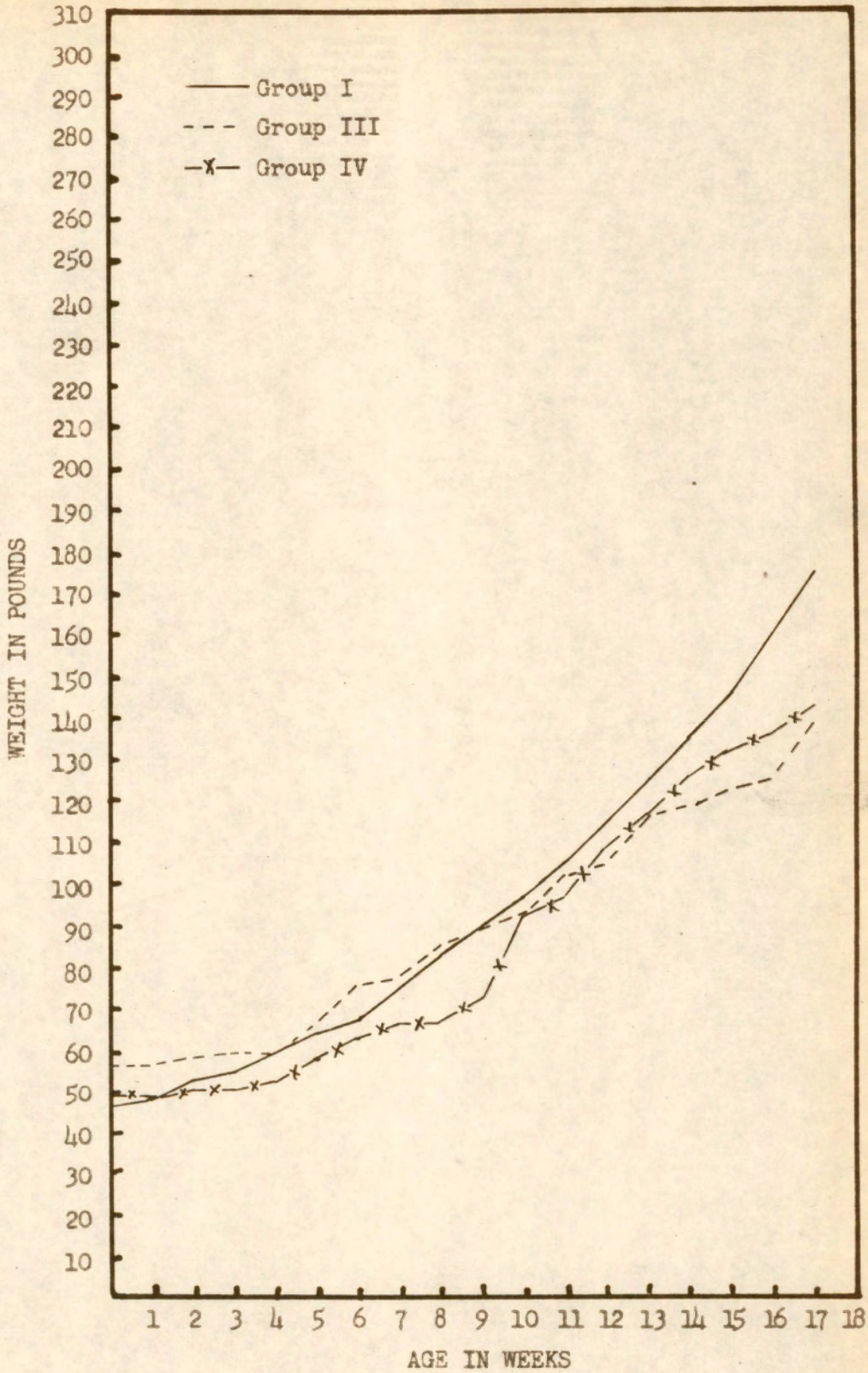

Figure 2. Average Weight of Jersey Calves.

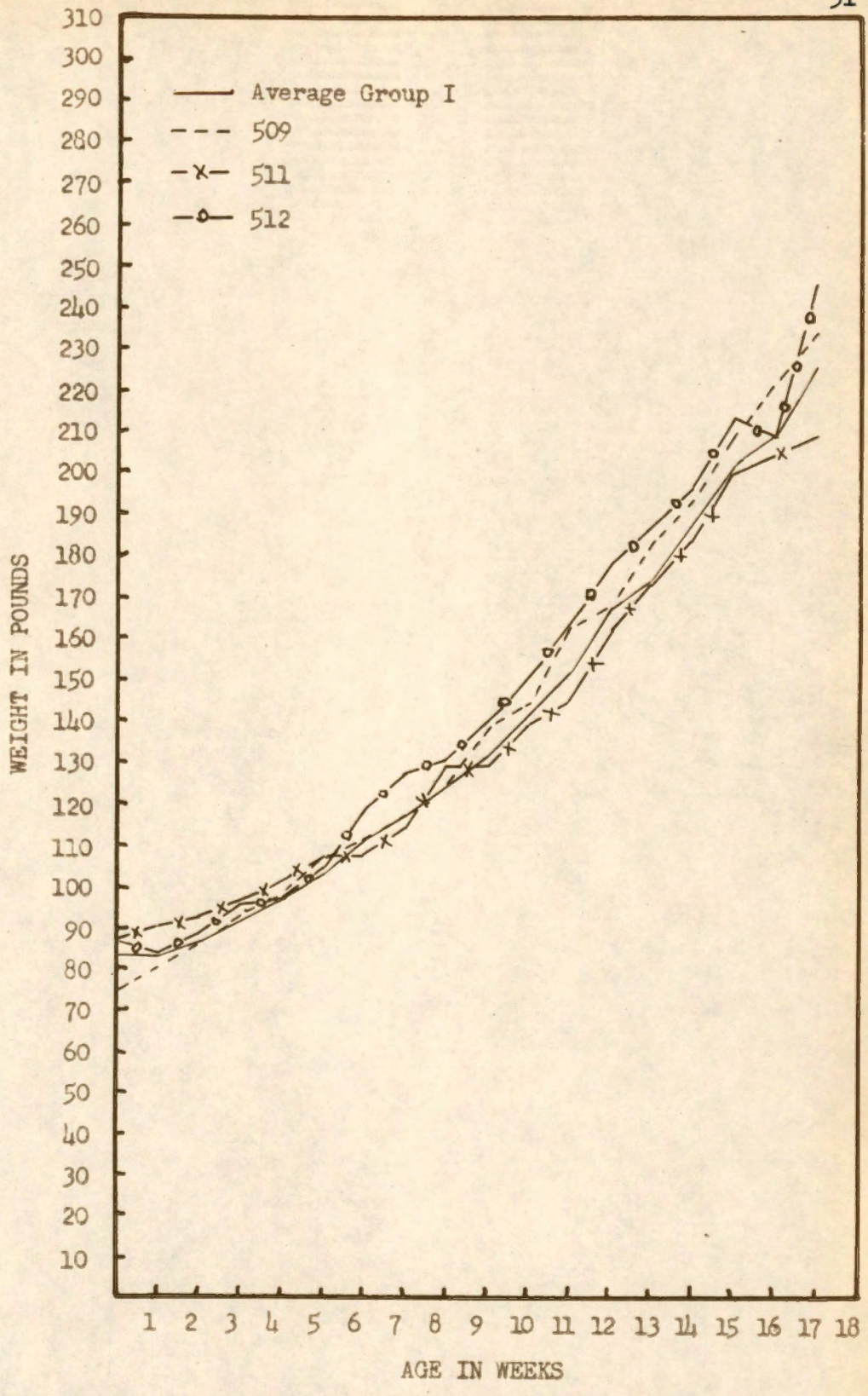

Figure 3. Individual Weights of Holstein Calves, Group I.

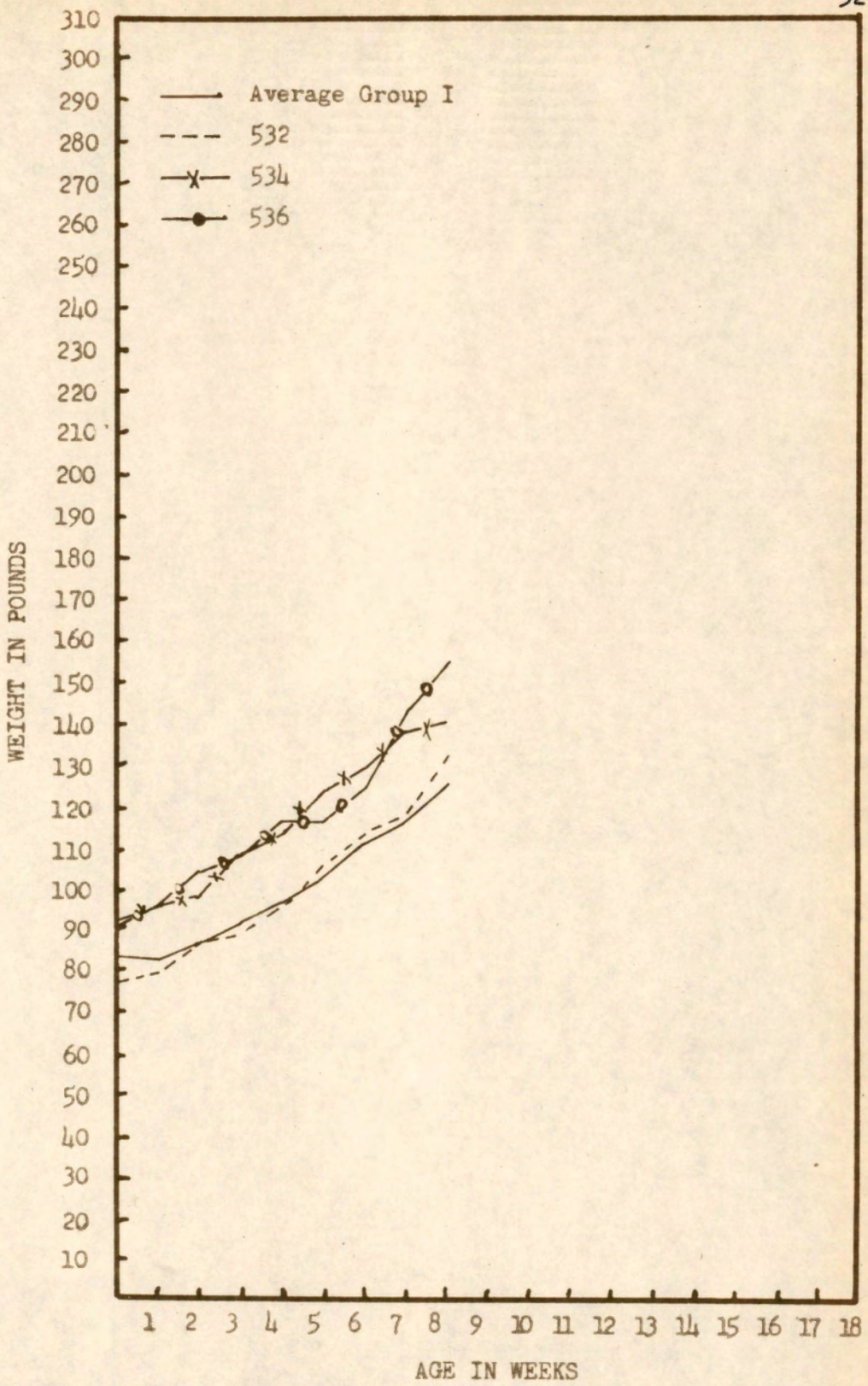

Figure 4. Individual Weights of Holstein Calves, Group II.

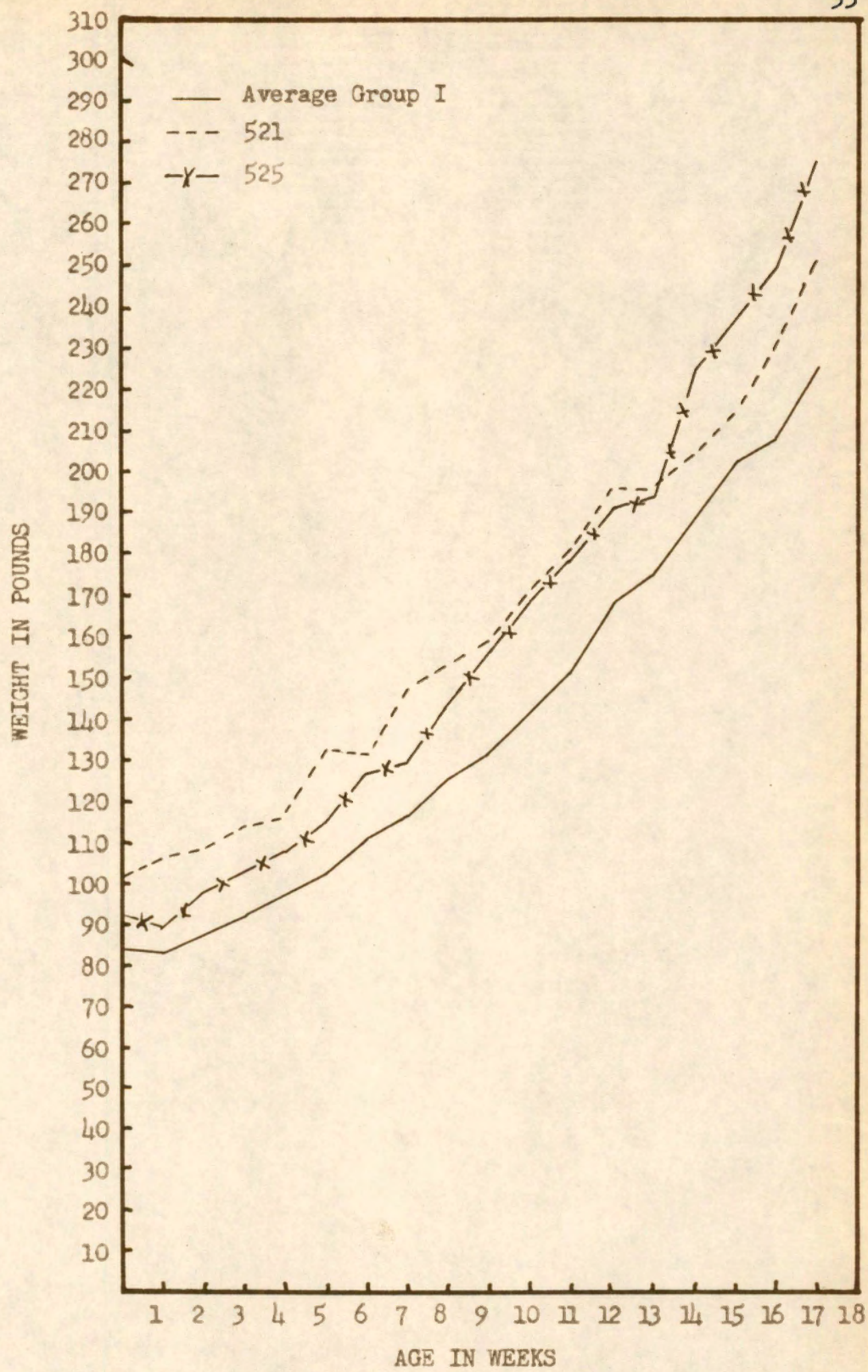

Figure 5. Individual Weights of Holstein Calves, Group III.

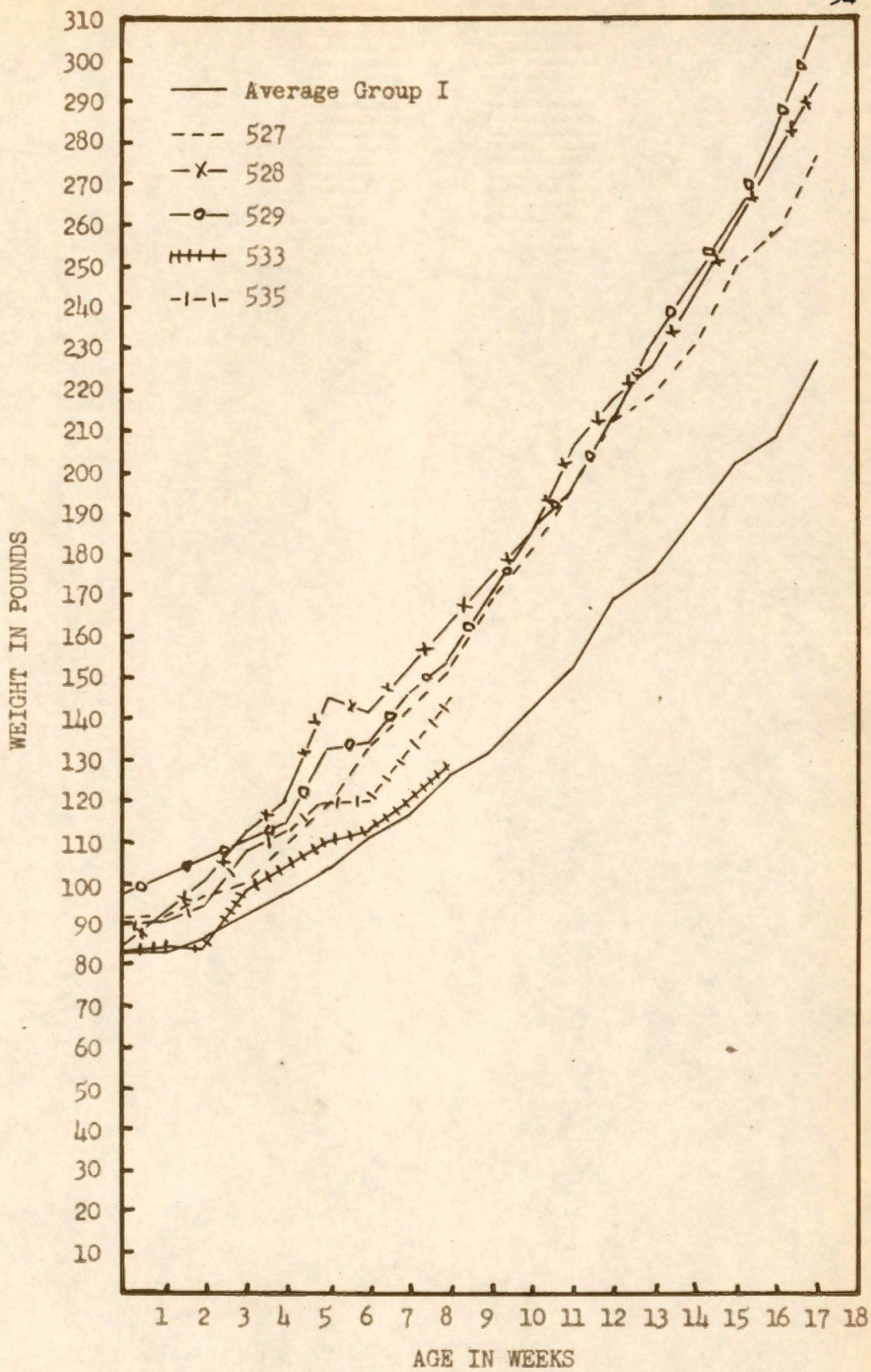

Figure 6. Individual Weights of Holstein Calves, Group IV.

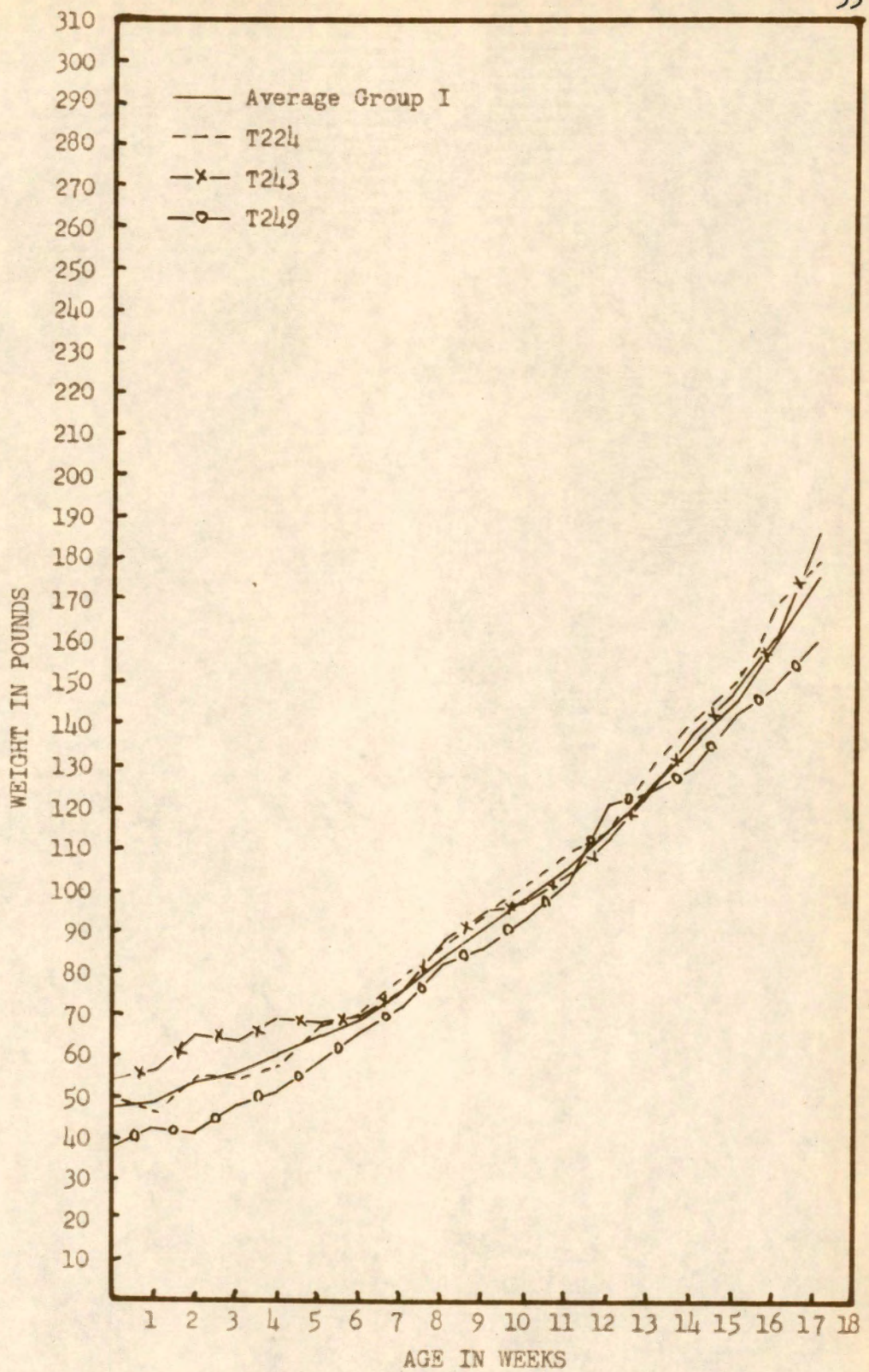

Figure 7. Individual Weights of Jersey Calves, Group I.

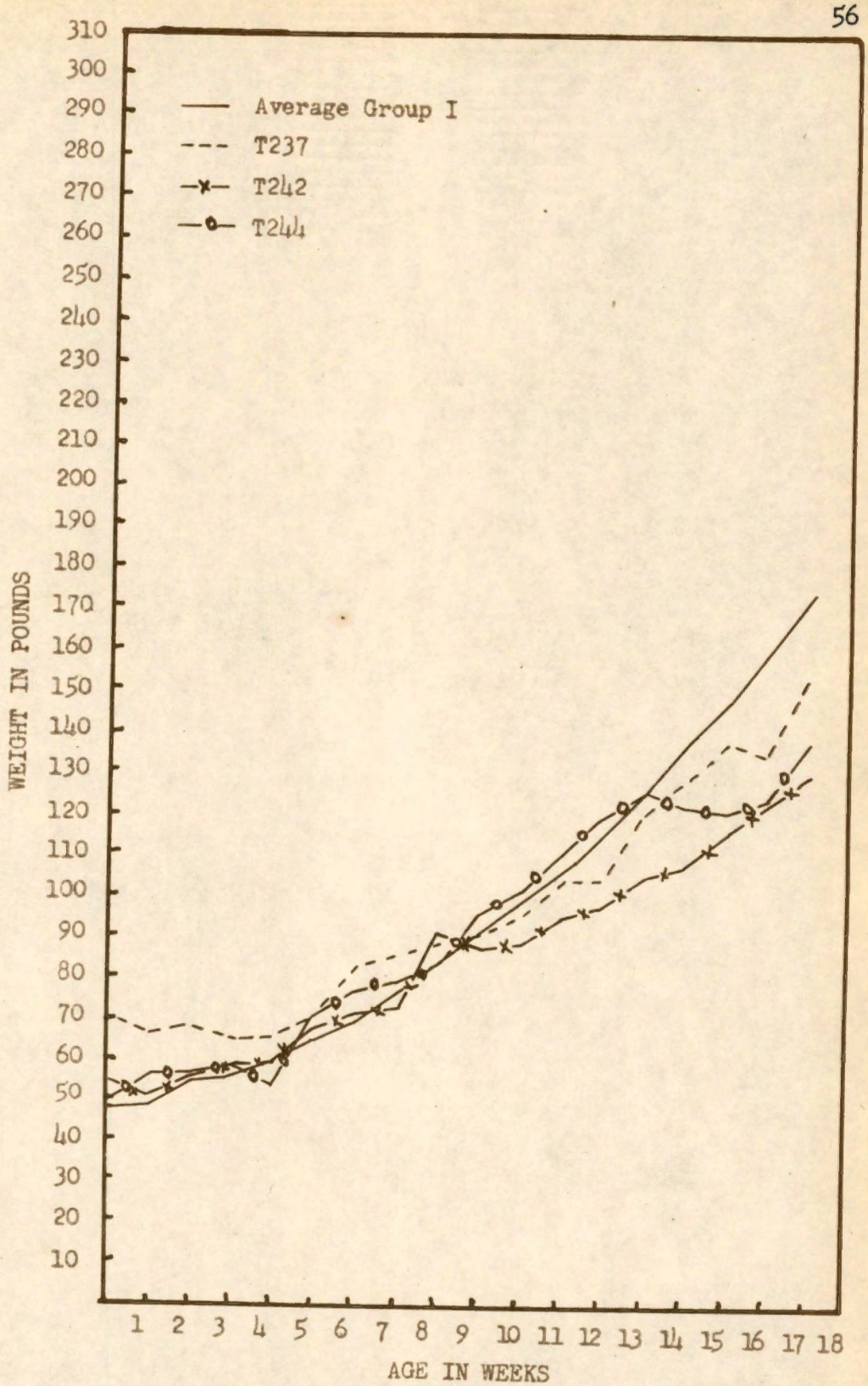

Figure 8. Individual Weights of Jersey Calves, Group III.

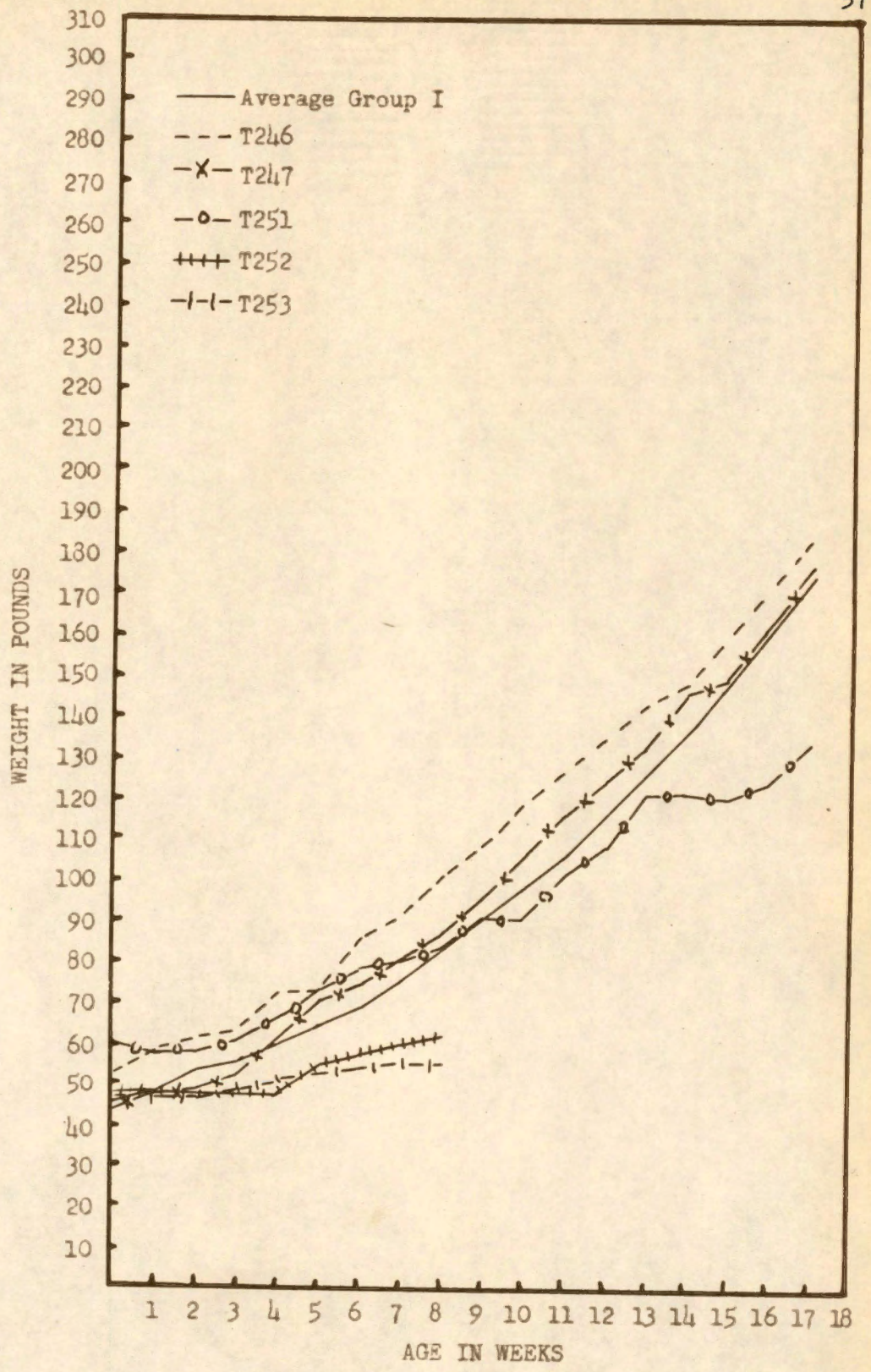

Figure 9. Individual Weights of Jersey Calves, Group IV.