

A STUDY OF SOME RELATIONS OF INTAKE
OF TOTAL DIGESTIBLE NUTRIENTS TO GROWTH
OF JERSEY HEIFERS

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INTRODUCTION

Growth is a complicated phenomenon which is of vital importance to growers of livestock throughout the world. It is a known fact that insufficient growth during the immature period has a marked effect upon the function of the dairy cow at maturity.

The meaning of growth, as defined by Eckles and Swett (3), is that series of physiological changes by which an individual of any species develops from the fertilized egg to maturity. When the parent cells unite at the time of fertilization, in some indefinable manner, a force is set free. This force has been called by some a growing impulse, growth tendency, and an inherent tendency to grow.

Increases in size may be brought about by multiplication of cells, enlargement of the individual cells, or deposition of material between the cells; however, multiplication of cells is generally accepted as being the most important. It must be remembered that the individual has an inheritance or growth impulse which makes it possible to attain a certain size, and even the greatest intake of food will not cause this limit to be exceeded. Nutrition, which is often looked upon as a controlling factor, can do no more than give free scope to the inherent tendency to grow, which the animal has received at birth.

As a general rule, young animals are permanently injured more often by the deficiency of some mineral or vitamin rather than by insufficient amounts of total digestible nutrients. However, young female animals are apt to be permanently stunted in size unless they receive sufficient nutrients to make normal growth before bearing their first young. With dairy cattle, especially, is this true, due to the heavy demand of nutrients during lactation. These demands take precedence over any use of nutrients for continued growth of the mother, and because of repeated reproductions and

lactations, the animals are unable to complete their growth; therefore, never attain normal size.

In measuring growth, not only should weight be taken into consideration, but also, skeletal growth. Growth, as used in this study, is measured by the weight of the animals and their height at withers.

PROBLEM

The purpose of this study was to determine the effect of the intake of total digestible nutrients on the growth of Jersey females. It is based upon the records of thirty-seven animals which were used in Projects 190 and 287 of the Oklahoma Station. These grade Jerseys were started on experimental rations at various times during the ten year period from May, 1927 to May, 1937. The data includes feed and growth records of each animal from birth to the age of twenty-four months. All statistics are calculated on a thirty-day basis.

As a general rule, these animals were fed whole milk for the first six weeks, this being gradually changed to skim milk. The skim milk was fed to the age of six months. Prairie hay was the primary roughage fed. Except in those cases where beet pulp replaced some of the prairie hay, cottonseed meal was the only concentrate fed. The calves were started on prairie hay and cottonseed meal as soon as they showed a desire for these feeds. As a rule, they received prairie hay during the latter part of the first thirty-day period, and cottonseed meal during the second thirty-day period. Since the protein required for growth and maintenance was amply supplied by the cottonseed meal fed, the protein intake was not considered in this study.

The weights and measurements of the animals were taken at thirty-day intervals, all weights and measurements recorded being the average of three successive days.

REVIEW OF LITERATURE

The total digestible nutrient requirements for growing dairy calves is a very important question, yet, comparatively speaking, little work has been done on this subject.

Eckles and Gullickson (4) conducted a study of various feeding standards at the Minnesota Station. They compared the Wolff-Lehmann, Kellner, Armsby, and Morrison feeding standards for growing dairy heifers. The Morrison standard was found to be too low for normal growth of dairy heifers up to about one year of age, and too high beyond that age. In arriving at these results, different levels of the nutrient requirement of dairy heifers based on the Morrison standard were used. The normal growth-weights of Eckles were used as a standard.

Gullickson and Eckles (2) also conducted a study on the nutrients required for maintenance by growing dairy cattle. In this study they found that when the revised net energy of alfalfa hay was used, the requirements for maintenance were lower than the requirements of the Armsby standard at weights below three hundred and fifty pounds and considerably above it at higher weights. Armsby's earlier method of calculating net energy value agreed more closely.

A. C. Bagsdale (8), at the Missouri Station, made a study of the feed consumption of dairy animals during the growing period. In this work he tried to keep the animals in good growing condition. His feeding plan was in accord with that practiced by the better class breeders who grow and develop their animals with reasonable rapidity. His data shows the average consumption of total digestible nutrients by animals which approximated or slightly exceeded the Missouri growth standard.

Much work has been done on the nutrition of immature animals, but for the most part it has dealt with the deficiency of some nutrient or nutrients

rather than with the level of intake of total digestible nutrients.

Herman (5), of the Missouri Station, studied growth and development of dairy calves on a milk diet. He found milk alone a sufficient diet for calves up to the age of six months. Calves beyond that age did not attain normal growth on a sole milk diet, nor could they survive very long. This study is a representative sample of the nature of most of the work which has been conducted on growth.

PLAN OF STUDY

The plan followed in this study was first to calculate the total digestible nutrient intake of the thirty-seven animals by thirty-day periods from birth to the age of twenty-four months. By use of the Minnesota normal (2), the total digestible nutrient intake was expressed in percentage for each animal, each period.

The same procedure was followed with the weights and heights at withers, using the Missouri normal (8) as a basis for the calculations.

The animals were then divided into groups according to the weight attained at the age of twenty-four months. The smallest animal in the group, being fifty-five percent of normal, comprised Group I while the remainder were placed in their respective groups, each of which included a range of ten percent. The group that was considered normal was made up of those animals whose weights were from ninety-five to one hundred and five percent of normal. The grouping is shown in Table I.

Table I.

Group	% Normal Weight	Number of Animals
1	Below 55	1
2	56 - 65	2
3	66 - 75	4
4	76 - 85	6
5	86 - 95	3
6	96 - 105	10
7	106 - 115	10
8	Above 115	1

The average percentages of normal weight, height at withers, and total digestible nutrient intake, were then calculated for each group by thirty-day periods.

DISCUSSION

The percentages of normal weight, height at withers, and total digestible nutrient intake for each of the eight groups are shown in Tables II to IX and graphically in Figures I to VIII, inclusively.

Group I consists of only one animal which attained the least growth of all. As shown in Table II and Figure I, her intake of digestible nutrients dropped during the second month, partially due to the discontinuation of the use of whole milk. It remained low until the eighth month after which there was an upward trend in feed consumption and at the age of twenty-four months the intake was within seven percent of normal. Her weight followed more or less in accord with the nutrient intake, however, not nearly as rapidly. The amount of nutrients consumed seemed to have little effect on her height at the withers.

Group II, which consists of two animals, the data of which is in Table III and Figure II, showed a similar decrease in nutrient intake the second month which was also due to the absence of whole milk. There was no appreciable increase in feed intake until the eleventh month, at which time the trend was definitely upward. Due to the heavy consumption of cottonseed meal and prairie hay, from the twentieth to twenty-fourth month, the level of intake was raised considerably. As in Group I, the weight again followed the intake of nutrients at a very gradual rate. The height at withers seems little affected by the nutrient intake and was approximately as that of Group I.

Group III, including four animals (Table IV, Figure III) followed the same general trend as the previous groups. There was a similar decline in the intake of nutrients during the second and third months, after which it approached the standard, exceeding it in the twenty-fourth month. The weight of this group very definitely followed the nutrient intake, the changes, of

Table II. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group I (1 animal).

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	77.6	96.7	63.3
2	67.7	93.4	34.0
3	56.1	88.2	41.9
4	50.0	84.3	34.3
5	54.7	83.2	39.2
6	54.3	82.9	41.7
7	48.2	79.6	36.7
8	46.2	78.2	43.6
9	44.1	77.8	45.5
10	45.0	79.5	49.0
11	47.8	80.3	51.5
12	47.3	79.4	52.5
13	45.5	81.8	55.9
14	45.9	83.1	54.8
15	48.1	84.3	59.7
16	48.5	83.3	62.6
17	49.3	84.3	59.8
18	49.5	83.4	62.5
19	48.7	85.7	64.5
20	50.7	85.0	59.0
21	50.0	86.1	66.7
22	52.0	87.7	77.8
23	52.8	88.2	87.4
24	53.6	88.9	93.3

Figure I. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group I.

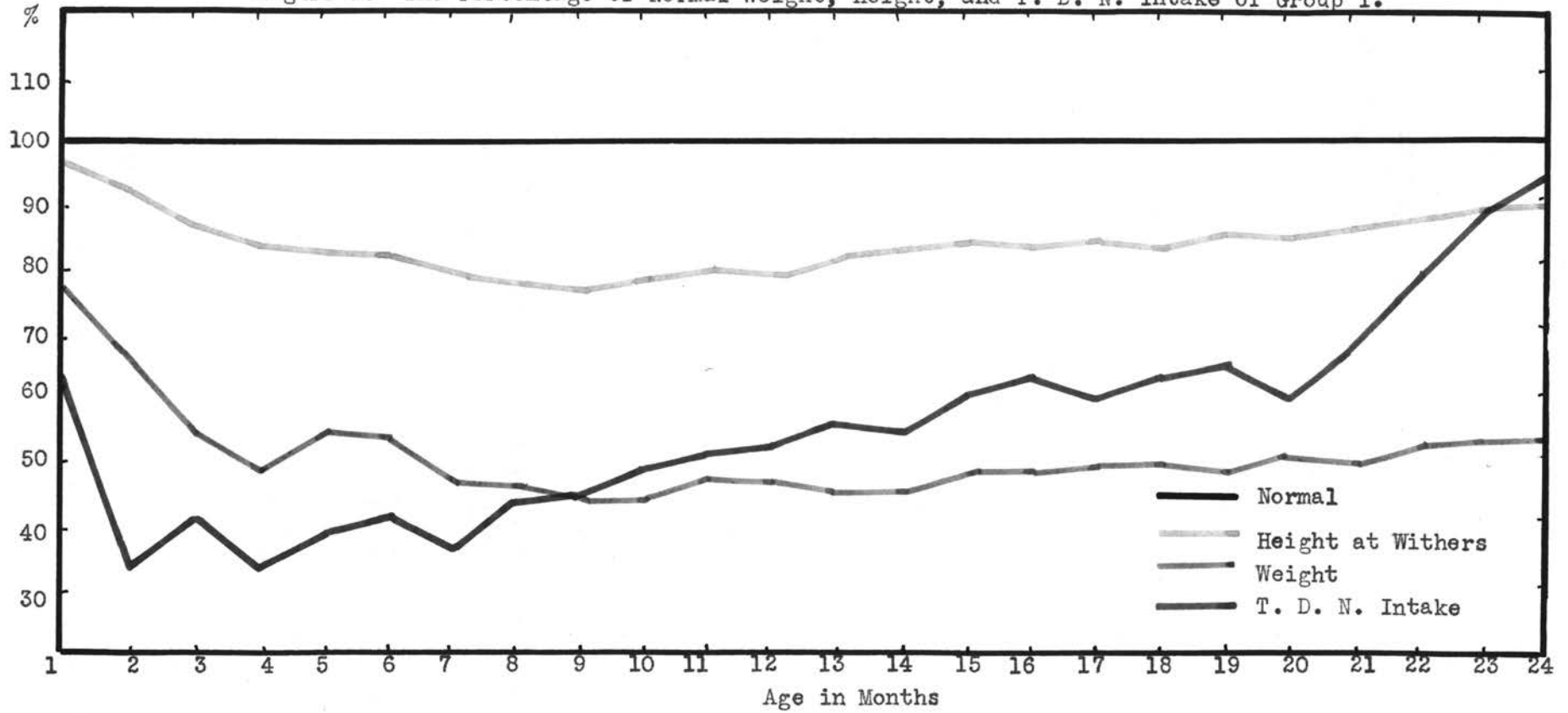
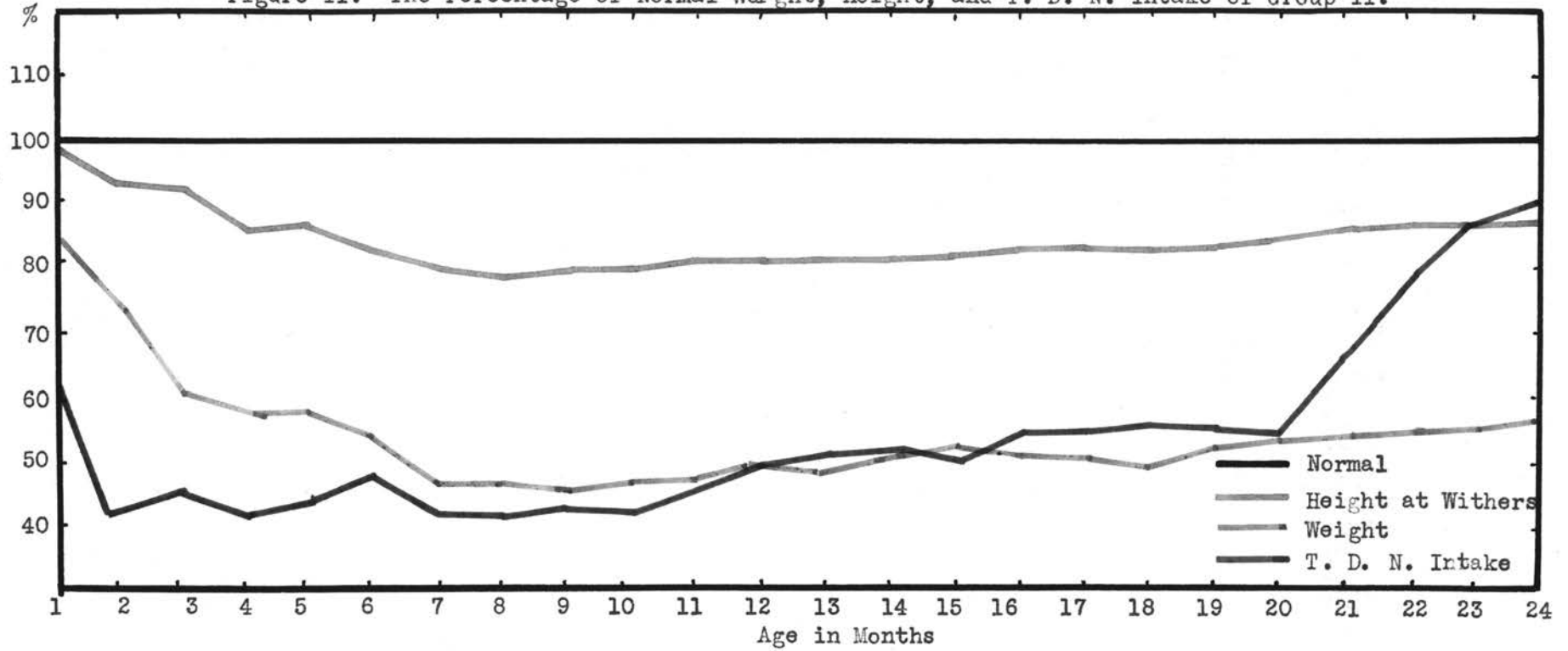


Table III. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group II (2 animals).

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	48.7	98.5	66.5
2	50.6	94.2	42.0
3	52.6	92.6	44.8
4	51.9	86.3	42.6
5	51.3	86.9	44.0
6	50.0	82.8	47.3
7	52.3	80.2	42.0
8	54.2	78.8	42.0
9	54.6	79.7	42.8
10	55.5	80.1	42.7
11	55.7	80.9	46.0
12	57.3	81.1	49.8
13	86.5	81.8	51.3
14	76.6	81.8	51.9
15	61.5	82.4	50.8
16	57.8	83.3	54.8
17	57.7	83.5	55.1
18	53.4	82.3	55.8
19	46.6	83.5	55.3
20	46.4	85.1	55.2
21	45.6	86.6	66.1
22	46.5	87.1	78.7
23	47.4	87.1	87.2
24	49.4	88.5	89.7

Figure II. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group II.



course, being more conservative. The height at withers of this group more nearly approached the standard than did the previous groups.

In Group IV (Table V and Figure IV), there were six animals. These animals consumed larger amounts of cottonseed meal and hay than the previous groups, accounting for the more moderate drop of the nutrient intake in the early months. The intake level approached normal quite rapidly, but the weight, although never dropping as low, did not follow the nutrient intake very closely. In height at withers, these animals exceeded those of Group III each month. The fifth group is composed of three animals. The behavior of this group is shown in Table VI and Figure V. A sharp contrast from the former groups is seen in the intake of total digestible nutrients for the first four months. These animals consumed more feed in the first few months. By the sixth month the intake of nutrients was up to normal, and from then on it followed what we would expect to see in a curve representing the averages of only three animals. The weight of these animals does not follow the changes in nutrient intake very closely. In contrast to the nutrients, the weight was above the normal for the first five months and below for the remainder of the period. The height at the withers varied very little during the entire twenty-four months. The reason for the decreased intake of nutrients during the twenty-fourth month was that one animal was off feed part of the time.

The sixth group, composed of ten animals, data of which is shown in Table VII and Figure VI, was considered normal. Their weights were within five percent of standard weight at the age of twenty-four months. The total digestible nutrients increased rapidly from the first month to the ninth month at which time it was considerably above the normal requirements. With the exception of the eleventh month, it remained above the normal. The average weight of these animals fluctuated very little during the twenty-four

Table IV. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group III (4 animals).

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	82.0	99.2	58.5
2	81.3	96.6	54.1
3	75.8	95.7	43.0
4	70.2	92.3	44.9
5	67.6	90.3	48.9
6	64.6	90.0	59.2
7	59.7	95.9	51.9
8	56.0	85.5	50.4
9	55.3	85.4	53.7
10	56.5	86.0	56.8
11	58.0	85.9	60.4
12	56.9	87.1	64.2
13	56.6	88.3	66.7
14	58.7	88.8	70.3
15	60.4	88.3	73.8
16	59.8	89.7	76.0
17	58.7	90.4	78.1
18	63.0	89.8	77.1
19	62.0	89.3	76.3
20	64.5	89.8	74.5
21	66.7	91.1	81.6
22	68.1	91.6	92.9
23	70.2	93.1	93.6
24	70.8	94.0	104.3

Figure III. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group III.

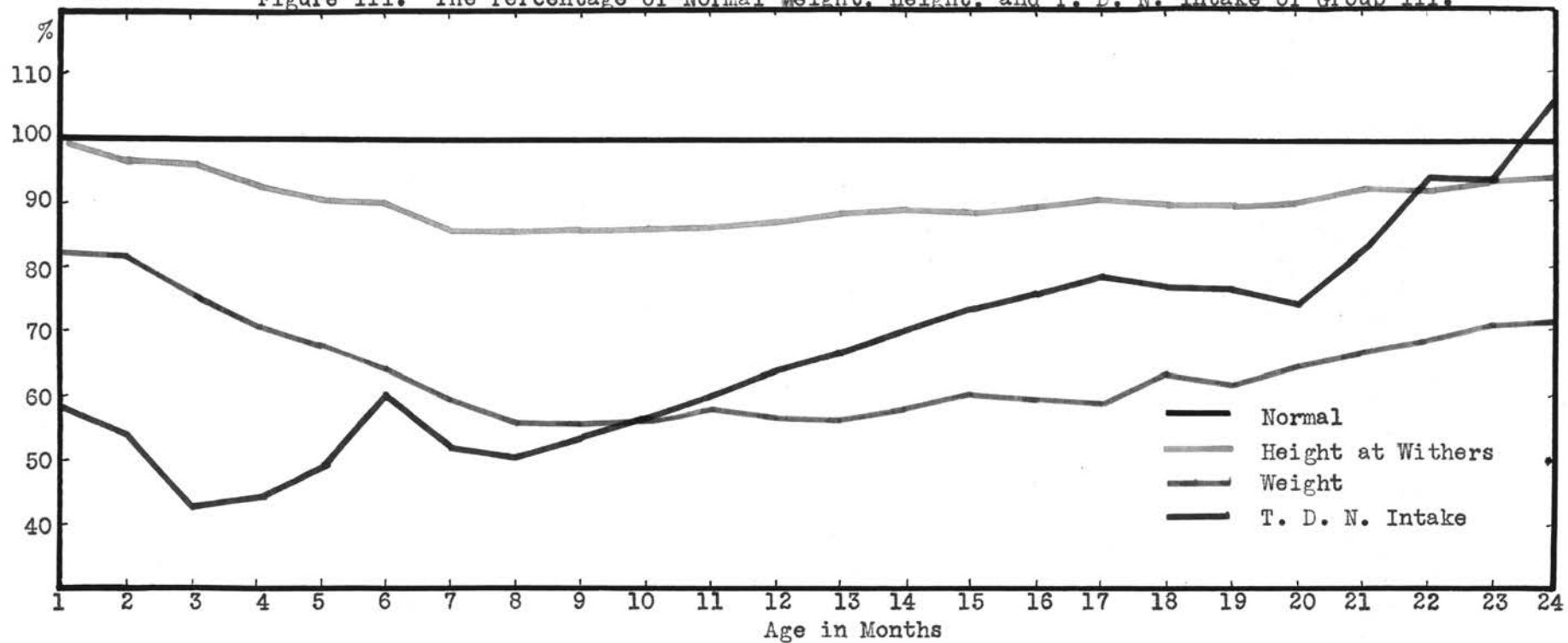


Table V. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group IV (6 animals).

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	94.3	100.8	64.6
2	95.9	99.1	66.9
3	89.0	98.8	58.2
4	86.1	97.6	60.7
5	82.2	96.0	66.4
6	72.8	93.7	64.0
7	71.5	92.9	61.2
8	72.8	91.6	62.2
9	71.5	91.8	68.1
10	70.3	91.9	66.5
11	70.7	91.2	73.7
12	70.8	92.9	79.0
13	71.2	92.5	81.8
14	71.1	92.8	83.7
15	71.6	92.5	86.6
16	72.4	94.3	89.7
17	71.5	93.8	87.1
18	72.5	93.9	87.8
19	72.0	95.1	89.6
20	75.0	94.4	96.9
21	76.9	95.8	94.7
22	79.8	95.4	102.8
23	79.9	96.8	101.1
24	79.8	96.9	110.7

Figure IV. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group IV.

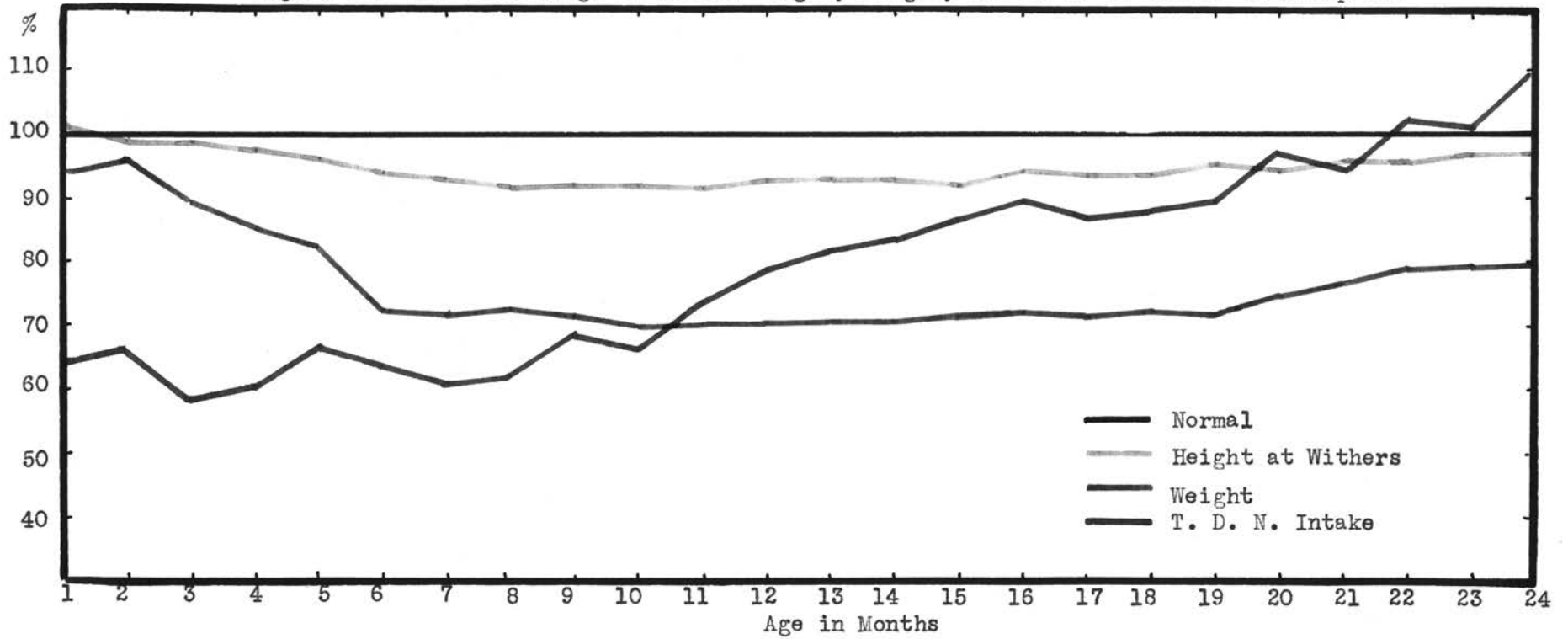
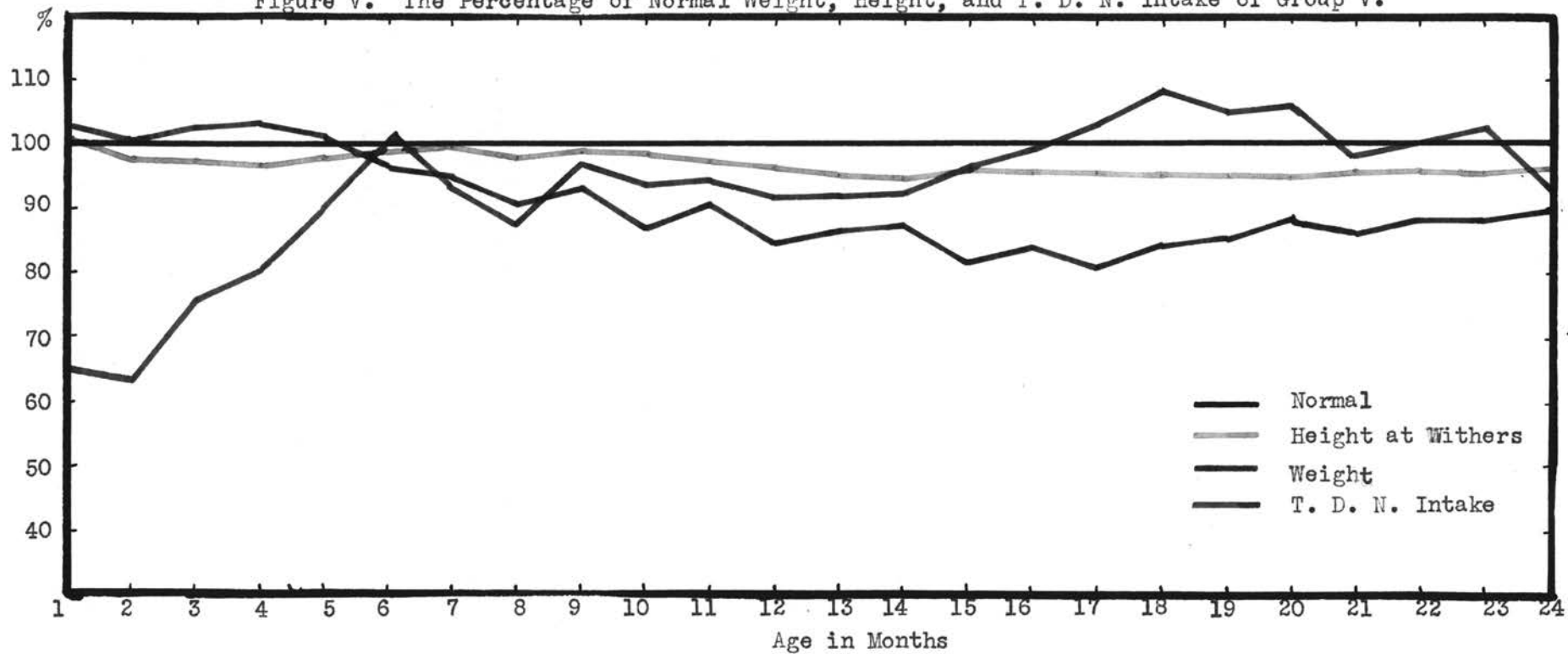


Table VI. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group V (3 animals)

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	102.5	100.7	65.0
2	100.4	97.9	63.4
3	102.2	97.7	76.0
4	103.2	96.6	80.1
5	101.7	97.8	90.0
6	96.7	98.7	100.6
7	94.5	99.9	93.4
8	90.8	97.9	87.3
9	93.7	98.8	96.8
10	87.0	98.4	93.4
11	90.6	97.5	94.3
12	85.0	96.8	92.2
13	86.7	95.6	92.2
14	87.8	95.4	92.4
15	82.3	96.7	96.0
16	84.2	95.7	99.4
17	81.1	95.6	103.3
18	84.5	95.6	108.3
19	85.6	95.7	105.5
20	88.1	95.4	106.4
21	86.5	96.0	98.5
22	88.3	96.1	100.3
23	88.2	95.6	102.5
24	89.1	96.4	93.9

Figure V. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group V.



months regardless of the nutrient intake. The height at withers of the animals was near the normal throughout. The decided drop in intake on the twenty-first month was due to four of the ten animals consuming less feed than in the previous month.

Group VII (Table VIII and Figure VII) consists of ten animals whose weights were from one hundred and five to one hundred and fifteen percent of normal at the age of twenty-four months. Their total digestible nutrient intake rapidly approached the standard during the first five months. The noticeable decrease, especially during the seventh month, is due to the discontinuation of feeding skim milk and to one animal not consuming very much hay during that period. The weight of these animals seems to have followed the nutrient intake rather closely. At the age of twenty-four months this group exceeded the normal weight by ten percent and was slightly above the normal in height at withers. The comparatively lower nutrient intake during the twenty-fourth month is due to two cows in the group refusing part of their cottonseed meal and prairie hay.

Group VIII, shown in Table IX and Figure VIII, includes only one animal. Her intake of nutrients was very inconsistent. The tremendous decrease during the eighteenth and twenty-fourth months is due to the small amounts of cottonseed meal and prairie hay consumed at that time. Her intake at one time, namely, during the twelfth month, was almost one hundred and fifty percent of the standard and varied greatly for the remainder of the period. Her weight seems to have followed the feed intake closely although not showing such great variations. In height at withers she exceeded the normal by about four percent.

Table VII. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group VI (10 animals).

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	96.2	98.7	58.0
2	97.8	96.0	67.3
3	96.1	95.6	76.0
4	92.9	95.4	79.6
5	93.5	96.0	86.2
6	93.7	96.4	94.1
7	92.5	96.9	95.8
8	94.1	96.2	105.8
9	94.5	96.5	111.0
10	92.8	97.0	104.2
11	94.5	97.2	94.7
12	93.3	98.2	102.3
13	94.9	98.8	101.0
14	94.7	98.4	108.7
15	96.2	98.7	117.7
16	96.8	98.2	117.9
17	97.1	99.0	115.0
18	96.0	98.7	117.0
19	97.5	99.2	117.5
20	98.7	99.0	120.0
21	99.3	99.7	120.1
22	99.0	99.2	108.8
23	98.6	99.0	109.8
24	99.0	99.2	103.2

Figure VI. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group VI.

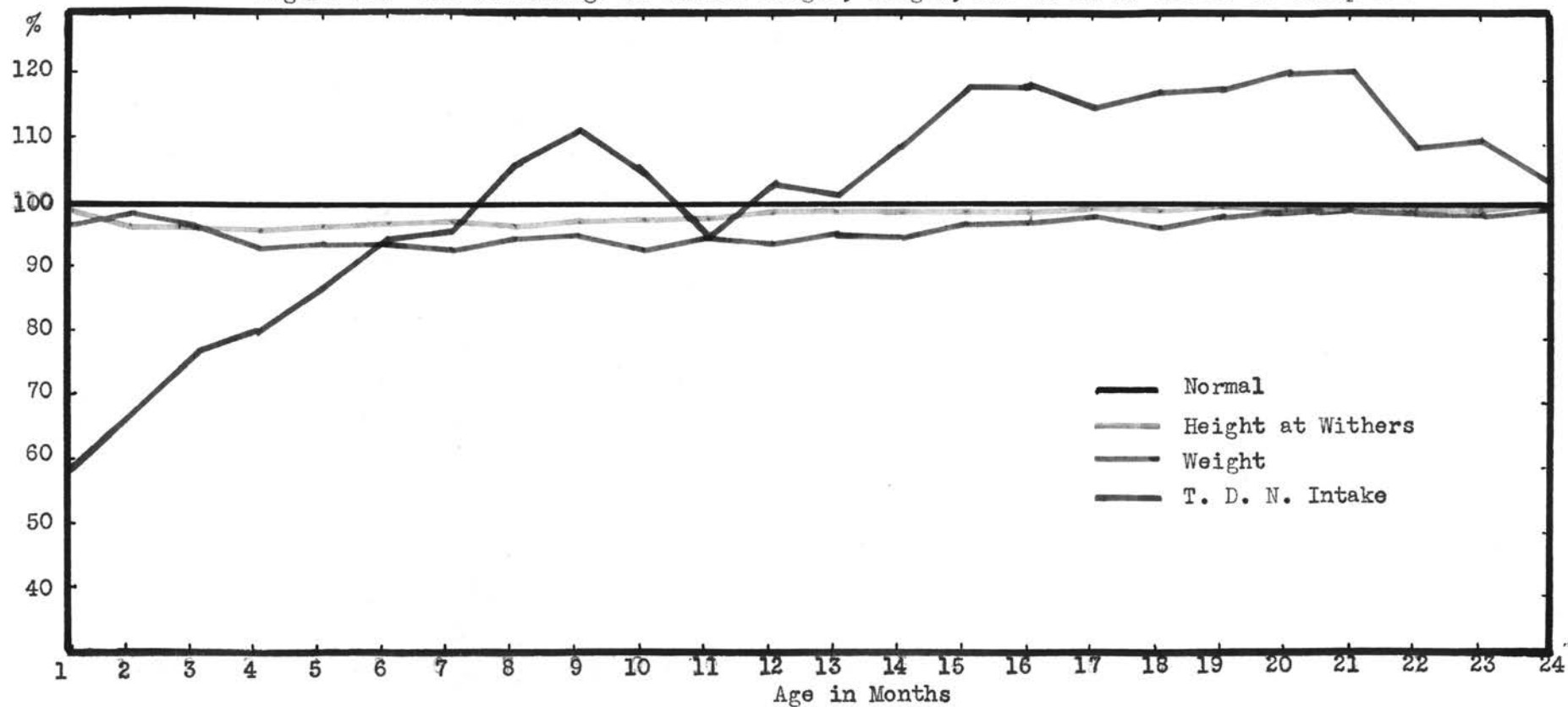
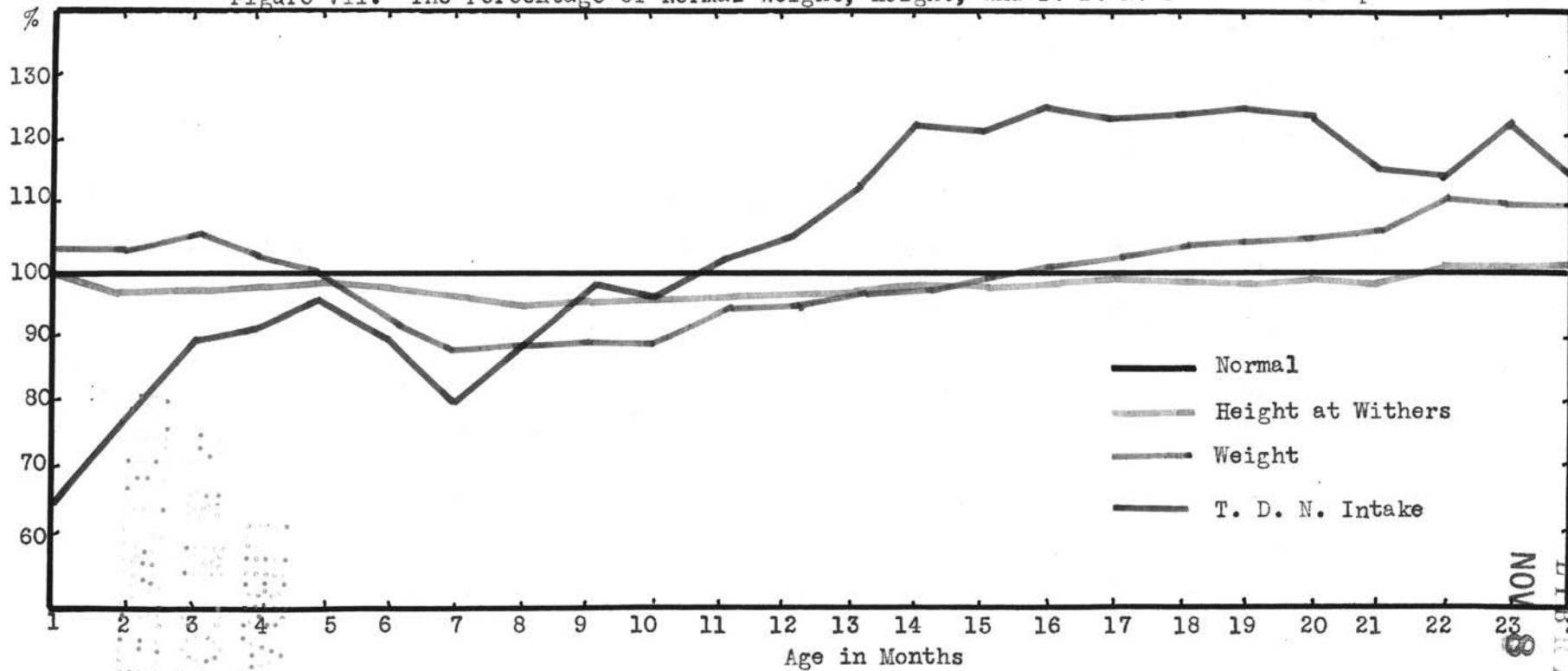


Table VIII. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group VII (10 animals).

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	102.3	98.6	66.6
2	103.0	97.5	77.8
3	104.4	97.8	88.8
4	101.5	97.8	91.0
5	99.2	98.0	95.3
6	93.0	97.0	89.6
7	88.4	96.0	79.2
8	88.7	95.2	87.9
9	89.0	95.5	97.3
10	89.1	95.7	95.7
11	92.7	95.7	100.5
12	94.8	96.4	103.9
13	96.3	97.5	111.3
14	96.9	97.4	121.6
15	98.7	97.3	121.5
16	100.4	98.7	124.1
17	101.7	98.7	123.2
18	103.9	98.9	123.8
19	104.7	99.6	124.7
20	105.3	99.6	123.5
21	106.4	99.1	116.1
22	110.1	100.1	114.8
23	110.0	100.1	121.9
24	109.9	100.5	113.3

Figure VII. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group VII.

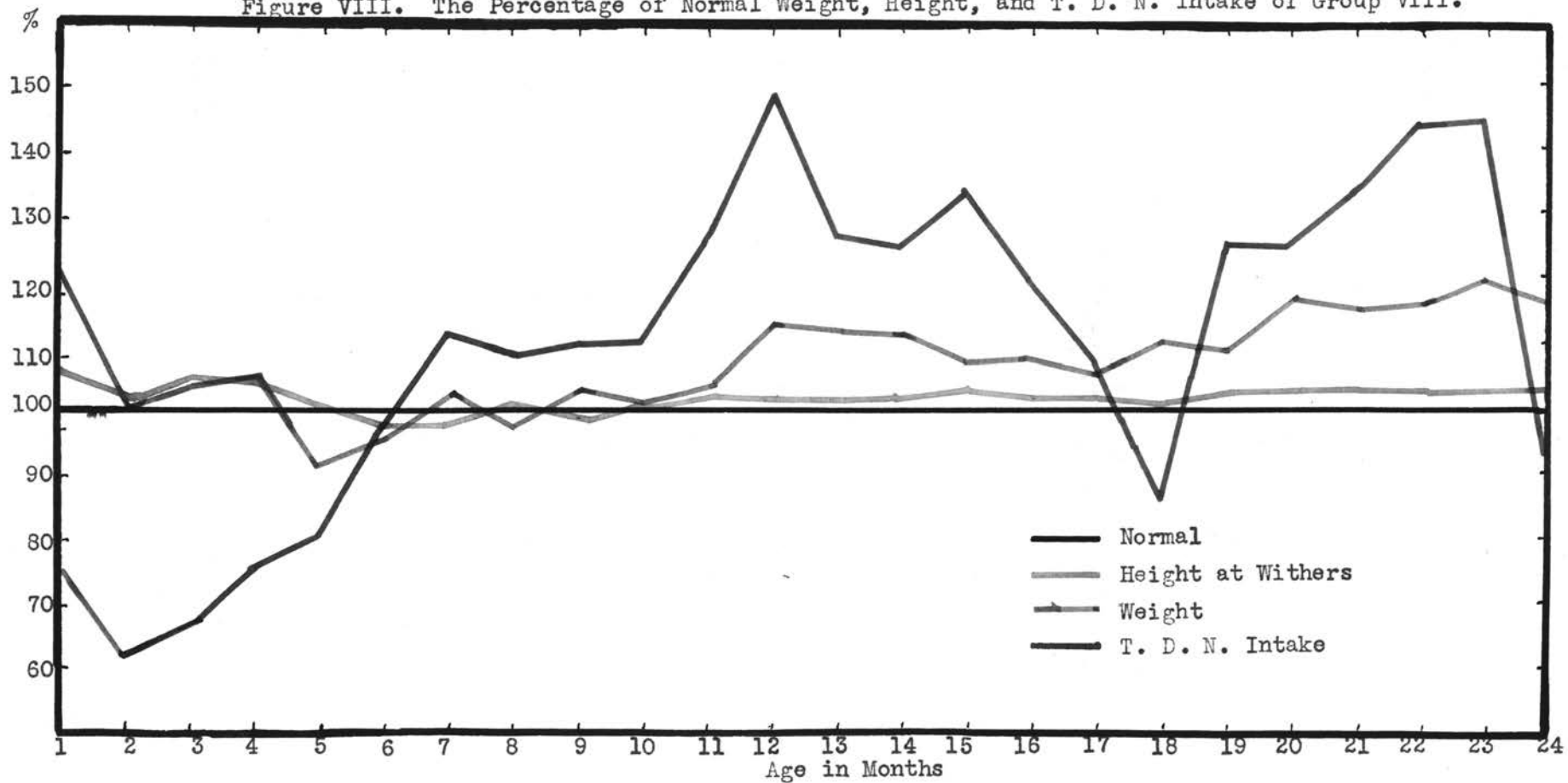


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Table IX. Percent Normal Weight, Height at Withers, and Intake of T. D. N. of Group VIII (1 animal).

Age in Months	% Normal Weight	% Normal Height at Withers	% Normal T. D. N. Intake
1	120.9	105.5	76.4
2	101.1	102.1	62.1
3	104.9	105.2	66.3
4	104.4	103.7	75.9
5	91.4	100.3	80.2
6	95.5	97.8	98.0
7	101.4	98.1	111.6
8	97.8	100.8	108.7
9	102.2	99.0	110.0
10	100.8	101.0	110.5
11	102.8	102.4	125.9
12	112.4	102.1	147.7
13	112.3	101.2	126.4
14	111.6	102.5	124.8
15	107.3	103.4	133.3
16	107.9	102.2	119.8
17	106.0	102.0	107.0
18	110.6	101.8	86.7
19	109.3	102.8	125.9
20	116.3	103.3	125.1
21	115.6	103.0	133.3
22	116.5	103.0	143.3
23	119.5	103.2	144.4
24	117.3	103.2	94.8

Figure VIII. The Percentage of Normal Weight, Height, and T. D. N. Intake of Group VIII.



RESULTS

Table X is a condensed summary of the intake of total digestible nutrients from birth to the ages of six months, twelve months, eighteen months, and twenty-four months, respectively. The average weights and heights of each group are also shown for each six month interval. The intake of nutrients is expressed in pounds and the weight and height in percent of the normal.

During the first six months, the nutrients consumed increased in accordance with the gain in weight of the group, with one exception, that being Group VI. Four animals in this group were extremely low in intake of nutrients the first month, causing the intake to fall below that of the fifth group which was lighter in weight.

At the end of the first year, practically the same condition exists, except that Group VII was lower than Group VI in total nutrients consumed. Every animal in this group showed an increase in consumption over the first six month period, but not as great proportionally as the other groups; hence, they consumed less nutrients than Group VI.

The consumption of nutrients to the end of the eighteenth month increased as the weight of the group increased with the exception of the second group. This, however, is not significant, because Group I consists of only one animal, thereby making the chances of variation immensely greater.

The data at the end of the twenty-fourth month shows that the various groups again consumed nutrients more or less proportionally to their respective weights. The one animal in Group I consumed more nutrients than did the average of Group II, but as previously mentioned, this is not significant.

An interesting feature brought out in Table X is that the nutrient intake of Groups III, IV, V, and VI, in which the weight difference is about

Table X. Relation of T. D. N. Consumption to Weights and Heights of Jersey Females.

	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
No. of animals	1	2	4	6	3	10	10	1

Average Pounds T. D. N. Consumed per Animal

Birth to 6 months	212.520	242.435	267.367	330.206	436.703	423.286	456.187	415.200
Birth to 12 months	720.823	723.608	880.688	1076.855	1442.930	1531.290	1486.067	1713.878
Birth to 18 months	1487.869	1418.616	1841.619	2198.867	2723.121	3003.073	3062.065	3222.687
Birth to 24 months	2575.985	2467.683	3109.256	3640.216	4187.481	4641.089	4785.221	5071.688

Percent Normal Weight

6 months of age	54.3	53.4	64.6	82.2	96.7	93.7	93.0	95.5
12 months of age	47.3	49.4	56.9	70.8	85.0	93.3	94.8	112.4
18 months of age	49.5	50.0	63.0	72.5	84.5	96.0	103.9	110.6
24 months of age	53.6	57.3	70.8	79.8	89.1	99.4	110.1	117.3

Percent Normal Height at Withers

6 months of age	82.9	82.8	90.0	93.7	98.7	96.4	97.0	97.8
12 months of age	79.4	81.1	87.1	92.9	96.8	98.2	96.4	102.1
18 months of age	83.4	82.3	89.8	93.9	95.6	98.7	98.9	101.8
24 months of age	88.9	88.5	94.0	96.9	96.4	99.2	100.5	103.2

ten percent, showed a marked degree of uniformity. There was a difference of about five hundred pounds in intake of nutrients between the groups. The intakes in the previous periods were similar but not so uniform.

The relationship of the weights of the eight groups is also worthy of mention. During the last eighteen months of the twenty-four month period studied, the average weights of the eight groups were consistently in the same order as they were at the end of the twenty-four month period. This indicates a remarkable uniformity in behavior in each of the groups after the age of six months.

It is obvious that the general trends of weight and height are in the same direction. As might be expected, weight is influenced more than height by the level of intake of nutrients. Another observation brought out very clearly is that in no case is the height at withers below eighty percent of normal. When the animals' weights were but fifty percent of normal, their heights were above eighty percent of normal. This indicates that in spite of the fact that an animal is underweight, the tendency is for her height to approach the normal.

The trend of the nutrient intake in relation to gain in weight of the individual animals is shown in Figure IX. A straight line was fitted to this data by the method of the least squares. This line shows graphically that for each one hundred pounds of gain in liveweight above three hundred and fifty pounds, 584.75 pounds of total digestible nutrients were consumed.

Figure X is a similar graph, calculated by the same method, showing the relationship of the gains in weight and gains in height at withers of the animals. The fitted straight line shows that, on the average, for every one hundred pound gain in liveweight, there is a gain in height at withers of 0.8815 inches.

Figure IX. Relation of Feed Intake to Gains in Weight

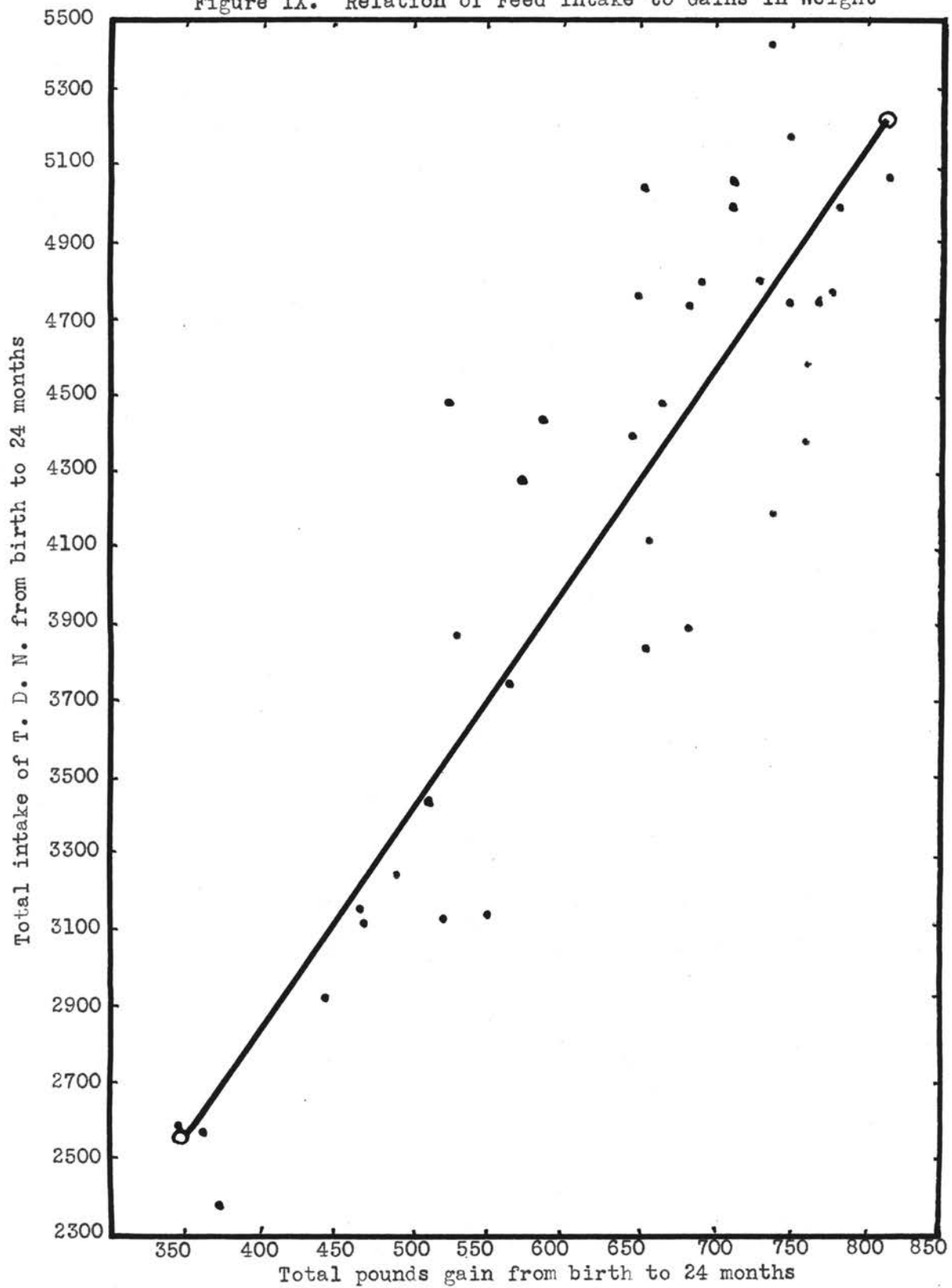
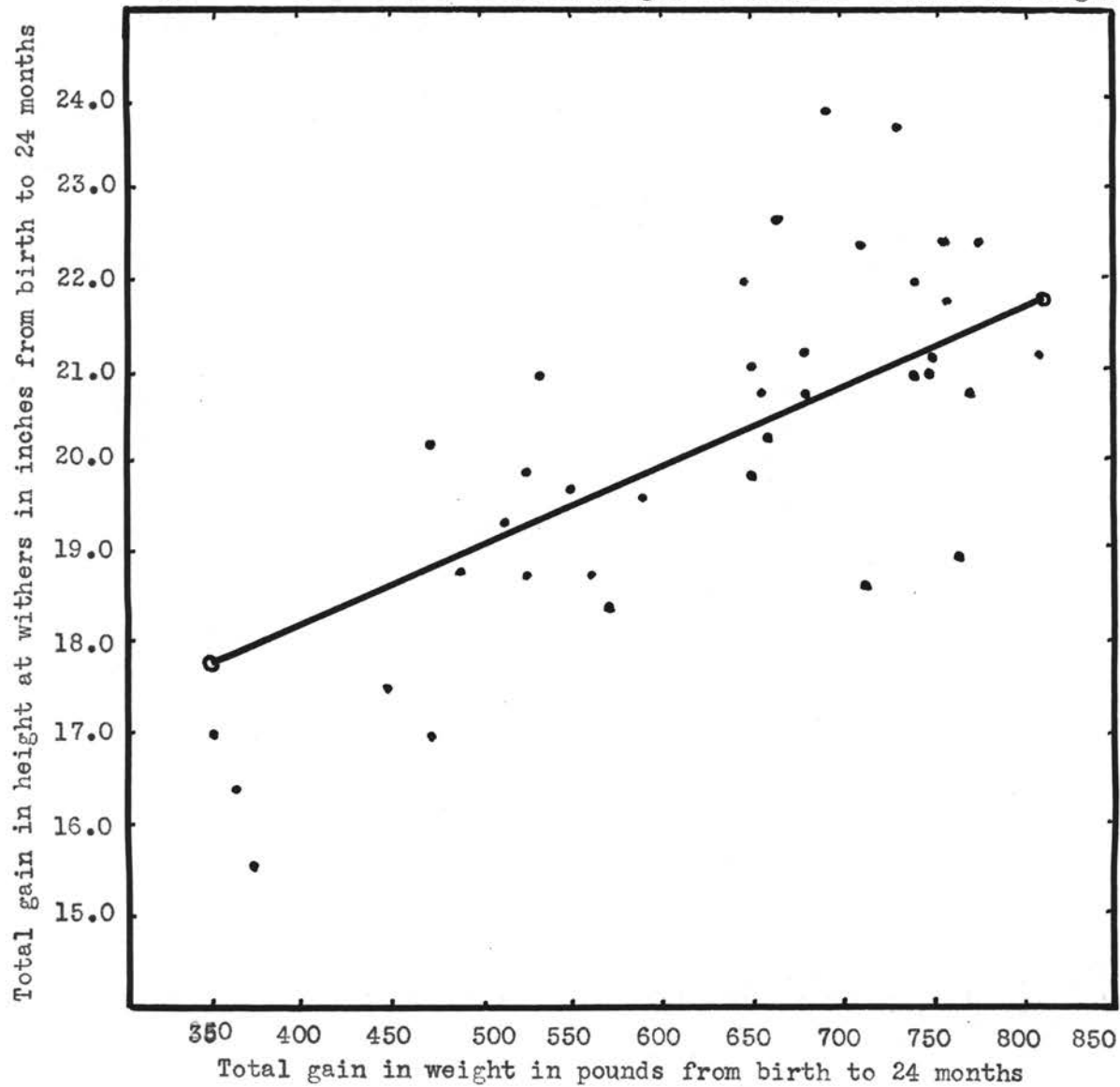


Figure X. Relation of Gain in Height at Withers to Gain in Weight



CONCLUSIONS

There is a direct correlation between the intake of total digestible nutrients and gain in body weight of Jersey heifers. There is, however, a considerable lag between increases in feed intake and increases in rate of gain in weight.

The height at withers is affected by the amount of nutrients consumed. This effect is not as pronounced as is the effect on weight. The animals attained eighty percent of normal height even when the nutrient intake was only fifty percent of normal.

The smallest gain made by any heifer during the two year period was three hundred and fifty pounds, and the largest gain was eight hundred and nine pounds.

On the average, 584.75 pounds of total digestible nutrients were consumed for every one hundred pounds gain above three hundred and fifty pounds.

For every one hundred pound gain in weight there is an increase in height at withers of 0.8815 inches.

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