

VITAMIN D AS IT AFFECTS GROWTH RATE IN
YOUNG SUCKLING LAMBS

by

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TABLE OF CONTENTS

Documents

| | |
|--|----|
| INTRODUCTION | 1 |
| REVIEW OF LITERATURE | 1 |
| History of Vitamin D | 1 |
| Requirements of Vitamin D by Sheep | 3 |
| Overdosage | 4 |
| Avitaminosis D | 4 |
| Forms and Chemistry | 5 |
| Source and Storage | 6 |
| Geographic Factors | 7 |
| Mode of Action | 8 |
| Specific Trials with Sheep | 11 |
| EXPERIMENTAL PROCEDURE | 15 |
| EXPERIMENTAL RESULTS | 16 |
| SUMMARY AND CONCLUSIONS | 24 |
| ACKNOWLEDGMENTS | 26 |
| LITERATURE CITED | 27 |

INTRODUCTION

The role of vitamin D in the metabolism of sheep and other ruminants has been studied only during the last decade. Information came slowly since experimental work with vitamin D is difficult because there is no acceptable chemical test available that can be used in assaying it. The keeping of animals out of the influence of solar radiation also imposes restrictions upon experimental work.

Much interest has been shown in recent years in the possible effects of vitamin D on the growth rate of young lambs. Australian workers have had considerable favorable response from lambs supplemented with the vitamin. It is a well known fact that lambs are born with a limited amount of stored vitamin D. Ewe's milk is also lacking in this particular vitamin. Possibly then lambs born during extreme winter conditions with relatively no sunshine might secure beneficial results from large doses of vitamin D during their early life, before they started consuming large amounts of feed. This experiment was designed to see if large doses of vitamin D would affect the growth rate of winter lambs in Kansas, raised under the usual Kansas conditions. However, this research has been limited and virtually no information is available on this subject, for our local area or any other area for the United States.

REVIEW OF LITERATURE

History of Vitamin D

It was towards the middle of the 17th century that Daniel Whistler wrote his thesis upon rickets in children, and it seems that the power of

cod-liver oil to prevent rickets in children was known to Scottish and European peasants from about this period. Discovery of the role played by vitamin D in nutrition, like many another in this field, depended upon the investigation of a human disorder.

It wasn't until the early part of this century that interest was focused on the possibility of sunlight playing a part in preventing rickets. Huldshensky, as cited by Ewer (1953) showed that it was the ultraviolet light that had this antirachitic power, and reported that suitable food could be as effective as sunlight in curing rickets in children.

During this same period Mellanby (1926) published the results of his nutritional studies in dogs, which established the vital part played by a fat-soluble factor in calcium and phosphorus metabolism. In the years that followed many workers undertook the experimental work involved in characterizing the chemical nature of both vitamin D₂ (calciferol), found in plants, and vitamin D₃ (7-dehydrocholesterol), the form which occurs in a wide range of animal species.

Elliot, et al (1926) reported the use of calcium and cod-liver oil to correct the "bent leg" disease found in young sheep. Their work was only a beginning, but it had the effect of encouraging later workers to regard a possible deficiency of this mineral as the primary factor in rickets in sheep. Auchinachie and Fraser (1932) found that calcium supplementation did prevent "bent leg" development in sheep kept on a diet relatively low in calcium and high in phosphorus (Ca:P ratio of 1:13). However, vitamin D alone, given as 10 ml. cod-liver oil daily was as fully protective as extra calcium and the vitamin D treated sheep had the highest weight gain.

Duckworth, et al (1943) showed that rickets could be produced in sheep by keeping them inside a shed and feeding a vitamin D-free ration. They also discovered that sheep fed a high caloric diet and with the fastest rate of gain in weight were those with the highest percentage of rickets.

Requirements of Vitamin D by Sheep

Andrews and Cunningham (1945) have done the only work to determine the exact amount of vitamin D required by sheep. They showed that for Corridale lambs over six months old, the approximate daily requirement of vitamin D was 180 international units per 100 lb. body weight.

Early New Zealand field trials, in which wethers were given 300 international units daily, while grazing green oats, showed that a number of wethers became mildly rachitic and two other wethers showed fairly severe rickets upon this level of intake.

In an experiment conducted by Duckworth and Associates (1943), in which Scottish blackface sheep were used, the dosage of vitamin D was at the rate of 200-250 international units daily per 100 lb. body weight and this was sufficient to prevent development of leg weakness and to insure good growth and normal blood composition.

Ever (1950) provided field evidence that suggested young growing sheep in countries of low latitude may receive insufficient solar radiation during winter if, at the same time, they receive a diet low in vitamin D. There appeared to be a high incidence of rickets among sheep grazing certain green feeds, especially young oats.

A complex of these factors determines the vitamin D needs of a sheep, namely, the amount of sunshine, the type of grazing and the level of calcium and phosphorus in the diet. These could be expanded to include quality and quantity of food, locality and environment, season, time of lambing, wool cover, condition of sheep and presence or absence of rachitogenic substances in the ration.

Overdosage

The work of Jeans and his associates as cited by Hawk, et al (1947), has emphasized that the requirements of vitamin D for optimum growth exceeds the antirachitic requirement.

The belief that excessive doses of vitamin D were toxic owed its origin in part to unfortunate experiences with an early German product "Vegartol" which probably contained an excessive proportion of toxisterol due to overirradiation of the sterol. Later studies have shown that the margin between the therapeutic and the minimum toxic dose of vitamin D is very wide. Several hundred times ordinary therapeutic dose must be administered daily for several weeks before toxic effects are noted. The chief symptoms of toxicity due to overdosage of vitamin D are anorexia and polyuria. Calcification of soft tissue, and particularly of the renal arterioles and the aorta are observed in advanced stages, although a hypertension is not encountered. The toxic effects disappear upon discontinuance of the dosage.

Avitaminosis D

Avitaminosis is first noticed in sheep when a fall in blood inorganic phosphorus occurs associated with normal total serum calcium values. It

is not until later that growing sheep will show lameness, especially occurring in the front legs, and this may subsequently progress to the stage of showing gross enlargement of the distal epiphyses of the leg bones, possibly related with bending outwards ("bow legs") or inwards ("knock knees"). The total serum calcium level will usually drop after three to four months. A fall in blood phosphate in sheep seems to be invariably associated with diminished appetite, therefore affected animals will generally make poor gains.

Observations made by Ewer (1950) indicated that both forms of vitamin D (D_2 , calciferol; D_3 delsterol) are equally as effective when used to prevent rickets in sheep.

Avitaminosis D in sheep appears to be restricted to the winter months and thus suggests that lack of effective short-wave solar radiation results in a deficiency of vitamin D_3 (irradiated 7-dehydrocholesterol), assuming there is no lack of the provitamin (which is apparently readily synthesized in the mucosa of the intestine, Scott et al (1949).

Forms and Chemistry

It is a known fact that irradiation of ergosterol with ultraviolet light waves converts only about 50 percent into calciferol. In the process a series of compounds are formed which in order of their appearance are: calciferol or vitamin D_2 , lumisterol, tachysterol, taxisterol, and two supra-sterols I and II, Tachysterol is also known today as A. T. 10, the initials A. T. standing for "anti-tetany" as it is used in the treatment of tetany. Of all these compounds formed by irradiation of ergosterol, only calciferol (vitamin D_2) has any antirachitic potency. Pure, anhydrous

ergosterol has the chemical formula $C_{28}H_{43}OH$; Calciferol (irradiated ergosterol) has an identical chemical formula. It's antirachitic potency is 40,000 U.S.P. units per mg. Provitamin D_3 (7-dehydrocholesterol) is found in cod-liver oil and also in skin of animals. Vitamins D_2 and D_3 appear about as potent as antirachitic for rats and for infants. For chicks D_3 is definitely more effective than D_2 .

Source and Storage

The distribution of vitamin D in nature is very limited. No vitamin D is found in living plant tissue. Many plant tissues when no longer living will, under the influence of sunlight, acquire considerable vitamin D potency due to the fact that the ultraviolet rays of the sun possess the ability to activate ergosterol. Properly cured hay, contains a very significant amount of vitamin D. Grains and their by-products contain practically none. All natural foods containing vitamin D are of animal origin. Cod-liver oil and fish oils are rich natural sources.

The need for having hay exposed to the sun in the curing process to give it antirachitic potency has been known since 1925, (Steenbock et al's). In more recent years, Thomas and Moore (1951) have shown that vitamin D is concentrated in the dead leaves and stems of hay and that the green leaves and top stems which were entirely green were without vitamin D activity.

Grant (1951) noticed that when rats on a standard rachitogenic diet were given an extract of green rye grass leaves, they developed more than usually severe rickets; whereas rats dosed with extracts of dead leaves showed an increase in bone calcification.

The animal body is able to maintain a reserve of vitamin D, the amount depending on the dietary supply and on the extent of exposure to the synthesizing influence of ultraviolet radiation.

The liver is the chief storage place of vitamin D in an animals body. Older animals, generally speaking, will not show signs of vitamin D deficiency until about 4-10 months after their ration has been devoid of the vitamin and they were allowed no exposure to sunlight. Young animals show a lack of vitamin D much sooner. It is believed that new born lambs are protected against a deficiency by the store in their bodies for only about three weeks.

Geographic Factors

Activation of provitamin D₃ (7-dehydrocholesterol) occurs in the skin of many animals following exposure to solar radiation. Tisdall and Brown (1929) observed the higher incidence of rickets with increasing latitude; this led them to believe that the disease could be anticipated wherever the winter sunshine has an incident angle of 35° or less. A more recent review of the available data on this point by Abrams (1952a) suggested that the quantity of vitamin D available to animals kept continuously outside in a latitude of 50° North is between 300 and 700 international units per 100 lbs. live weight.

The effectiveness of the sunlight is dependent upon the lengths and intensity of the ultraviolet rays which reach the body. It is ineffective through ordinary window glass because the latter does not allow sufficiently short wave lengths to pass through. The greater the distance the rays have to travel, the longer is the minimum wave length which reaches the earth and

the lesser the intensity of the ineffective radiations. Thus sunlight is more potent at noon than in the morning or evening and more potent at high altitudes. These variations are of large importance in vitamin D nutrition. Therefore, animals which are on pasture during the summer never suffer from the lack of the antirachitic factor even though their diet is practically devoid of it. In the wintertime the story is different. At best, the animals are outside only a part of the day, there are generally a much smaller number of sunny days, and the sunlight which does reach the animal is not nearly as effective as during the summer. Morrison stated (1948), that "under most conditions of practice in the latitude of the northern United States, it is unsafe to rely on exposure to sunlight to provide the antirachitic factor during the winter months. Table 1 shows the altitude of the sun at Manhattan, Kansas, at different hours of the day and also at different seasons of the year.

Mode of Action

A relationship is known to exist between vitamin D intake of mammals and (a) mineral absorption from the intestine, (b) calcium, phosphorus and phosphatase levels of the blood (c) bone formation, (d) growth rate, (e) reproduction and (f) efficiency of food utilization.

McLean (1941) claimed that there are two distinct actions of vitamin D occurring at widely different dosage levels: first, the antirachitic action for which relatively only small amounts are essential and secondly, the "calcemic" effect with several hundred times the anti-rachitic dose. Hibbs (1950) attempted to raise the serum calcium level in cows at the end of pregnancy and in post parturient period by giving massive doses (10×10

international units daily, 5-7 days before calving) in an effort to avoid the hypocalcemia associated with milk fever indicated some degree of success. However, Swan (1952) noticed lesions of calcification of the aorta in many cows given this very high vitamin D₂ intake.

Harris and Innes (1931) tried to explain how vitamin D affects various tissues of sheep. They stated that the effect of the vitamin on the retention of calcium and phosphate is the result of two factors: (1) increased absorption from or diminished excretion into the gut; (2) increased excretion by the kidneys. As more vitamin D is given, the second effect overtakes the first, especially when it is in excess.

Nicolaysen (1937) showed that vitamin D directly influenced the absorption of calcium from the intestine.

Harrison and Harrison (1942) developed the concept that the center of vitamin D action was the kidney tubular epithelium. More advanced work along this line by Zetterstrom (1951) showed that vitamin D activated alkaline phosphatase from the kidney, intestines and bone, and that a suspension of kidney mitochondria containing glutamate responded to phosphoregulated vitamin D₂ by increased oxygen intake. If further work will show the above reactions to be specific, they certainly link satisfactorily with the contention (Robinson, 1923; Robinson and Rosenkelm, 1934) that alkaline phosphatase is necessary for ossification; and it is well-known that the kidneys show the highest concentration of alkaline phosphatase. Therefore, the mode of action of vitamin D may be in the kidney by "activating" alkaline phosphatase.

Experimental work by Ewer, (1949) supports the belief that vitamin D

Table 1. Altitudes of sun at Manhattan, Kansas.

| | 8 h. | 9 h. | 10 h. | 11 h. | 12 h. | 1 h. | 2 h. | 3 h. | 4 h. |
|-----------------|------|------|-------|-------|-------|------|------|------|------|
| Summer Solstice | 37 | 48 | 59 | 69 | 74 | 69 | 59 | 48 | 37 |
| Equinox | 23 | 33 | 42 | 48 | 51 | 48 | 42 | 33 | 23 |
| Winter Solstice | -- | 15 | 22 | 26 | 27 | 26 | 22 | 15 | -- |

All altitudes are given in the nearest degree.

Latitude of Manhattan, Kansas ($39\frac{1}{2}$ N).

effects a transfer of phosphorus from soft tissue to bone in rachitic animals on a low-phosphorus diet.

Specific Trials with Sheep

In (1935) Leslie noticed the high incidence of rickets in young growing lambs and hoggetts in New Zealand. He found that most outbreaks occurred during the late autumn and winter months. He reported beneficial results in increased rate of gain and decreased bone troubles when these lambs were treated with vitamin D.

Franklin, Reid and Johnstone, as cited by Franklin (1953), noticed the occurrence of vitamin D deficiencies in experimental sheep housed in indoor pens. The experiments and field observations of these men led them to believe that a vitamin D deficiency might occur among grazing animals in southern latitudes in Australia. At the same time Ewer and his associates (1950) were obtaining results which supported the view.

Ewer has referred to the experiments of Tisdall and Brown (1927, 1929) which showed the importance of sun altitude and, therefore of latitude, as a factor in effective ultraviolet irradiation. With sun altitudes of 35° or less, very few of the short rays within the effective ultraviolet range for conversion of sterols to vitamin D in the animal body reach the earth's surface.

At Launceston, in Tasmania, in midwinter the noonday sun altitude is only 25° and for eighteen weeks of the year, nine weeks before and after midwinter, it never exceeds 35° , which is given as the critical altitude by Tisdall and Brown (1927).

Franklin (1953) reports an experiment at "Frodsky" when stud Corriedale ewe and ram weaners were run on dormant winter pasture and, in addition, were given a supplement of hay. Some groups were given two subcutaneous doses of 10^6 i.u. vitamin D_2 in olive oil, during the middle of May and again two months later, whereas the control group received no vitamin D_2 supplement. Very little change in body weight was noticed over the 15-week period, May 15 to August 28th, and there was no significant advantage in vitamin D treatment.

Green (1953) reported an experiment at "Vancluse," two groups, each of 25 cull Corriedale weaners were grazed continuously on green-feed oats the 15 weeks, May 15th to August 28th. One of the groups was treated twice with vitamin D_2 (10^6 i.u. subcutaneously), and at the same periods as those at "Frodsky".

It was found that:

1. There was little difference in liveweight increases in either treated or untreated groups during the first eight weeks of the experiment.
2. During the following seven weeks, July 10th to August 20th, the weaners treated with vitamin D_2 continued to grow at a steady rate whereas many of the controls lost weight (nine animals) or remained more or less stationary (fewer animals).
3. Five weaners in the control group were lame or slightly stiff eighty days after the experiment had started. The sheep receiving vitamin D_2 were not affected.
4. There was a reasonably close correlation between the behavior of individual animals in the control group and serum-calcium and inorganic phosphorus levels.

5. Macroscopic examination of the costochondrol junctions of a rib-section from one of the lame sheep in the control group showed the characteristic bone changes of rickets.

6. All treated animals were in excellent condition at the end of the experiment whereas there was a very definite "tail" in the control group.

Franklin (1953) reported that the weaners in the 1948 Tasmanian experiment did not show any significant benefits from treatment with vitamin D₂. The explanation given for the difference between 1947 and 1948 results are as follows: In 1947 the weaners were grazing on a pure stand of oats, whereas, in 1948, the oats were grown on land sown down originally with subterranean clover and, for some weeks before termination of the experiment, a vigorous growth of clover provided a longer portion of the grazing. Seasonal conditions varied considerably in the two years. Rainfall records during the four winter months (May-August inclusive) were 3.72, 5.33, 4.24 and 3.11 inches respectively in 1947 and only 1.98, 0.71, 2.18 and 1.68 inches respectively in 1948.

Finally, whereas in 1947 cull weaners in poor condition were used, those used in the 1948 experiments were heavier and in better condition. There was evidence from the 1947 results that the heavier weaners in the control, untreated group suffered less from vitamin D insufficiency than their lighter and poorer group mates, and this was confirmed in later experiments.

Ewer (1948) conducted experiments at McMaster Field Station in 1948 to study the effect of latitude on weaners grazing on green-feed oats. A line of small, poorly-developed Merino weaners from New England was divided into two groups, one of which was grazed on native pasture

and the other on green-feed oats. The oat group was further divided into three subgroups, one of which was drenched with phenothiazine, the second was drenched with phenothiazine and supplemented with vitamin D₂ and the third group was left untreated.

The beneficial effects of the vitamin D₂ supplement were apparent within five weeks and became more striking as the experiment continued. The changes, in favor of vitamin D₂ supplementation, were noticed in serum calcium and, to a lesser degree, serum inorganic phosphorus levels, body weight, condition and mortality rate.

Franklin (1953) reported an experiment conducted at the Cressy Station in which they studied the effect of condition on growth response and also on wool production when vitamin D supplements were used. In this experiment Corriedale weaners in good condition and poor crossbred weaners have been together on green-feed oats for 144 days from 21st April, 1950, to 12th September, 1950.

Corriedale weaners starting the experiment in good condition without vitamin D supplementation gained 34.3 pounds while the same type lambs dosed with one million I.U. of vitamin D gained only 32.4 pounds. However, crossbred weaners in poor condition supplemented with one million I.U. of vitamin D gained 38.5 pounds whereas, the same weaners left untreated gained but 15.8 pounds. Differences in average wool weights were not as great.

Neither the Australian experiments nor those of other workers have given a clear indication of the vitamin D requirements of weaners. In some years the response to vitamin D supplements has been striking and field

experiences, not reported here, have sometimes been even more dramatic. In other instances, no significant response has been obtained.

In Australia, the big problem is to decide under what broad circumstances one is justified in recommending the use of a vitamin D supplement. Ewer has recommended supplementation during the winter of all immature sheep in Tasmania and in the winter-rainfall area of Australia. This is not in accordance with the experiences of all other researchers. The general opinion is that such fractions or recommendations would lead to disappointing results and might serve to discredit the use of vitamin D altogether.

EXPERIMENTAL PROCEDURE

This experiment was designed primarily to observe the influence of large vitamin D dosage in young lambs and its affect on their growth rate.

All the information presented here was obtained from observations of 18 single lambs born between December 6 and 18, 1954, in the College pure-bred Rambouillet flock.

The lambs were weighed at 2 days of age and their birth weight and sex were used to divide the 18 lambs in two approximately equal groups. Group A (treated lambs) weighed 11.0 pounds at birth and included six males and three females. Group B (untreated lambs) weighed 11.1 pounds and included six males and three females.

On December 23, 1953, the lambs were weighed and those in group A were dosed with 300,000 I.U. of vitamin D₃. The lambs were weighed at approximately two week intervals. On January 4, 1954, the lambs in

group A were again given vitamin D₃ supplementation, but this time the dosage level was 600,000.

During the course of the experiment, the lambs were nursing their mothers. They also had access to a creep but made very little use of the creep feeder until the 1st of February. Starting on the 20th of January the ewes received a ration of silage, one-half pound protein supplement and two pounds grain.

On March 18, the lambs were bled and a calcium and phosphorus determination was made on the blood.

EXPERIMENTAL RESULTS

It should be pointed out that the wide variation in average weights between the control group and the treated group was apparently due to the fact that in the control group three out of the nine lambs were unthrifty. The ewes of these three lambs were checked and it seemed that they were as good in milk production as the average of the other ewes.

At the time of the first dosage the control group seemed equal to the treated group in all visible respects. The initial dosage consisted of 300,000 I.U. of vitamin D₃ and was administered on the twenty-third of December. At this time the control group averaged 17.1 pounds per lamb whereas the treated lambs averaged 17.0 pounds per lamb. Approximately two weeks later the lambs were weighed again and at this time the treated group was dosed with an additional 600,000 I.U. of vitamin D₃. The average weight of the control lambs was 23.3 pounds while the lambs that had been treated two weeks previously averaged 27.2 pounds or an average increase of 3.9 pounds per lamb. At this time a creep feeder was made available

to the lambs but no significant quantity of feed was consumed until the first week of February.

A very important environmental factor which may have had some bearing on this experiment was that the month of December and the first-half of January was the period in which the Manhattan area received considerable moisture and had very unfavorable weather conditions. It was during this period that Manhattan had it's lowest temperature of the winter and received very little sunshine.

On January 15, another weight was taken on all lambs and the treated lambs, that had received 900,000 I.U. of vitamin D₃, had an average weight above the control group. At this weigh period it was noticed that three of the control lambs were unthrifty. These three lambs never recovered from this condition. The birth weight of these three unthrifty lambs was 9, 10 and 12 pounds. The average being 10.3 pounds whereas the overall average was 11.0 pounds. However these three lambs were not the small lambs in the lot at the time of birth, as the birth weights on all the lambs ranged from 9 to 12 pounds.

The treated lambs continued to show an average weight above the control group throughout the entire experimental period. However the treated lambs did not continue the rapid increase in gains over the controls after the first 21 days of the experiment.

Table 2 shows the weight of each individual lamb at each weighing period. It also includes the birth weight, sex and experimental treatment of each lamb. From this table the effect of treatment can be seen on individual lambs rather than the groups.

Serum calcium and serum inorganic phosphorus tests showed no consistent difference between the controls and those treated with vitamin D₃. However, the mean, as indicated in table 4, was slightly higher for both calcium and inorganic phosphorus in the treated lambs.

Table 2. Weights of individual lambs at each weighing period.

| *Lamb no. | Sex | Birth wt. | 12/23 | 1/4 | 1/15 | 1/29 | 2/11 | 2/27 | 3/15 |
|-----------|-----|-----------|-------|-----|------|------|------|------|------|
| 1 | M | 12 | 25 | 38 | 49 | 61 | 70 | 81 | 93 |
| 2 | F | 9 | 18 | 28 | 35 | 41 | 47 | 56 | 63 |
| 3 | M | 12 | 23 | 29 | 38 | 48 | 58 | 66 | 80 |
| 4 | F | 10 | 20 | 27 | 33 | 40 | 48 | 56 | 68 |
| 5 | F | 11 | 19 | 30 | 39 | 48 | 55 | 59 | 63 |
| 6 | M | 12 | 18 | 29 | 37 | 46 | 54 | 70 | 85 |
| 7 | F | 10 | 14 | 19 | 24 | 30 | 35 | 40 | 48 |
| 8 | M | 11 | 19 | 26 | 38 | 46 | 55 | 67 | 84 |
| 9 | M | 12 | 17 | 27 | 33 | 44 | 50 | 63 | 73 |
| 00 | M | 12 | 19 | 27 | 33 | 41 | 50 | 63 | 79 |
| 11 | F | 11 | 15 | 19 | 23 | 29 | 33 | 40 | 50 |
| 12 | M | 11 | 16 | 25 | 34 | 42 | 50 | 61 | 73 |
| 13 | M | 11 | 17 | 23 | 31 | 38 | 46 | 61 | 78 |
| 14 | M | 12 | 15 | 25 | 31 | 36 | 42 | 44 | 48 |
| 15 | M | 11 | 14 | 24 | 33 | 41 | 47 | 55 | 62 |
| 16 | M | 9 | 11 | 18 | 20 | 25 | 29 | 29 | 35 |
| 17 | M | 11 | 14 | 23 | 30 | 40 | 46 | 64 | 72 |
| 18 | F | 9 | 12 | 21 | 29 | 34 | 41 | 52 | 61 |

* All lambs were single lambs.

• Treated lambs

° Control lambs

Table 3. Average increases in pounds for each group at each weighing period.

| | Birth to 12/23 | 12/23 to 1/4 | 1/4 to 1/15 | 1/15 to 1/29 | 1/29 to 2/11 | 2/11 to 2/27 | 2/27 to 3/15 |
|----------|----------------------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|
| *Group A | 7.0 | 10.2 | 8.2 | 8.7 | 6.9 | 11.3 | 9.4 |
| 'Group B | 7.0 | 6.2 | 6.6 | 7.4 | 6.3 | 8.2 | 11.5 |

*Group A-----received 900,000 I.U. of vitamin D₃.

'Group B-----controls.

Table 3 shows the average gains in pounds between weighing periods for each group. The widest spread in gains between the two groups occurred during the first period after the initial vitamin D₃ dosage was given. During this period of December 23, to January 4, the treated lambs averaged 4.0 pounds per lamb over the controls. The treated lambs outgained the controls except during the last period of the experiment, when the controls gained 2.1 pounds per lamb more than the treated lambs.

Figure 1 shows the growth curve as measured at the time of birth, at time of initial dosage (December 23) and at the second dosage (January 4). Treated lambs showed an average weight increase of 3.9 pounds over the control lambs on January 4. However the treated lambs did not continue the rapid increase in weights over the controls during the entire experimental period.

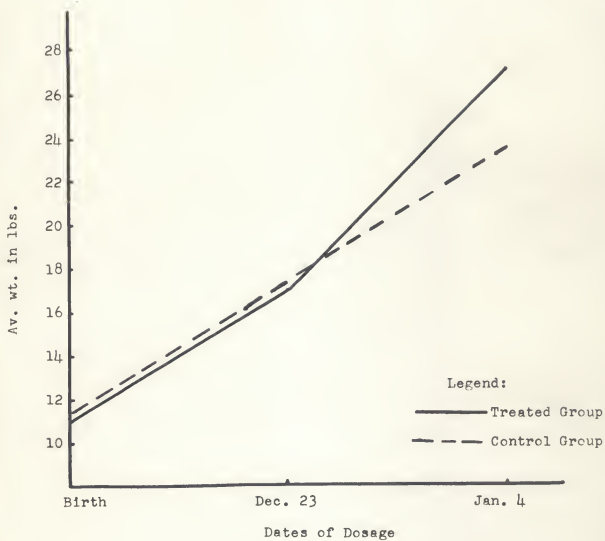


FIG. 1. Average weights after initial dosage.

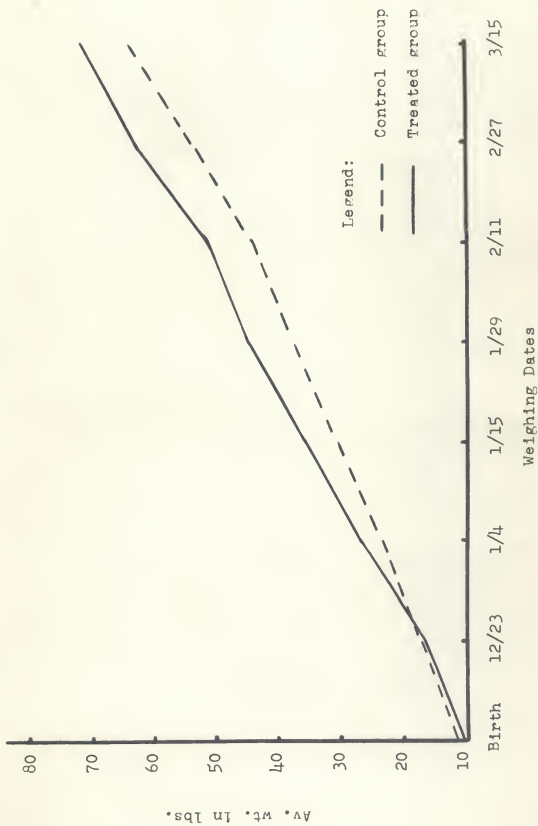


Fig. 2. Average weights per group

Table 4. Calcium and phosphorus determinations.

| Lamb no. | calcium mg % serum | inorganic phosphorus mg % serum |
|-------------------|-----------------------|------------------------------------|
| '00 | 15.7 | 9.76 |
| * 1 | 15.6 | 7.63 |
| ' 3 | 15.6 | 8.24 |
| ' 4 | 15.6 | 7.89 |
| * 6 | 15.0 | 8.88 |
| '11 | 17.2 | 8.12 |
| *12 | 14.8 | 8.61 |
| *13 | 15.0 | 10.02 |
| '15 | 15.4 | 8.61 |
| *18 | 19.4 | 8.61 |
| mean for controls | 15.7 | 8.17 |
| mean for treated | 16.1 | 8.86 |

* treated lambs

' untreated or controls

Figure 2 shows the growth curve of the treated and untreated lambs during the entire experimental period. At the time of the last weighing the treated lambs averaged 8.4 pounds heavier than the control lambs. This difference was due largely to the three unthrifty lambs in the control group.

SUMMARY AND CONCLUSIONS

Eighteen lambs were divided into two equal groups. Group A was treated with 900,000 I.U. of Vitamin D₃ whereas group B was left untreated. Average birth weights of the control group were 11.1 pounds while the average for the treated group was 11.0 pounds. At the time of the first weighing after the initial dosage had been given the treated lambs averaged 3.9 pounds more per lamb. At the end of the trial the treated lambs averaged 8.4 pounds per lamb more than the control lambs.

Lambs in the control group, except the three unthrifty lambs, seemed equally as growthy and healthy at the end of the experiment as the treated lambs. The only possible beneficial effects noticeable on the treated lambs was the rapid average increase in gains during a short period (3 weeks) after the initial dosage. December and the first-half of January were the most severe part of winter in the Manhattan area during the past winter. The lambs born the earlier part of December possibly received a boost from the large vitamin D dosage. This possibly may be one reason why the unthrifty lambs appeared in the control group. However, many other environmental and hereditary factors could have been responsible. It appears that if any benefits were derived from the large vitamin D dosage, that they were derived during the early life of the lamb. It was during the period when the lambs diet consisted of only the ewe's milk (which is without the vitamin) along with a very unfavorable climate and limited sunshine.

A number of factors determine the vitamin D needs of sheep chiefly, the amount of sunshine, the type of grazing and the level of calcium and phosphorus in the diet. There could be added the quality and quantity of

food, locality and environment, season, time of lambing, wool cover, condition of sheep and presence or absence of rachitogenic substances in the ration.

The following conclusions are based on observations made during the experimental period:

1. In this study the lambs treated with vitamin D outgained the controls. However, lamb numbers were too small to be conclusive.

2. The great difference in average weight of the treated over the control group was due to three unthrifty lambs in the control group.

3. No explanation can be given for the appearance of all unthrifty lambs to appear in the control group, unless that the large vitamin D doses gave the treated lambs a better start in their early life.

4. It appears that the controls would catch up in average weight with the treated lambs had this experiment been continued over a longer period of time.

5. Further research work is needed before any definite recommendations can be given in regards to vitamin D supplementation to young lambs.

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VITAMIN D AS IT AFFECTS GROWTH RATE IN
YOUNG SUCKLING LAMBS

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VITAMIN D AS IT AFFECTS GROWTH RATE IN
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The exact role and wide importance of vitamin D in the metabolism of sheep has come into prominence only during the last decade. The inter-relationships of calcium, phosphorus and vitamin D in bone formation has been recognized for some time.

There are several factors which determine the vitamin D requirements of sheep, several of which are the amount of sunshine, the type of grazing and the level of calcium and phosphorus in the diet. To these could be added the quality and quantity of food, locality and environment, season, time of lambing, wool cover, condition of sheep and presence or absence of rachitogenic substances in the ration.

The presence of sufficient vitamin D in the ration generally improves calcium and phosphorus assimilation and tends to offset the effects of mineral imbalance. Provided that there is at least a minimum amount of vitamin D available the optimum Ca/P ratio is about 2:1. The approximate daily requirements of vitamin for sheep are 180 international units per hundred pounds body weight, whereas the recommended allowances are given as 300 international units of vitamin D per hundred pounds body weight.

This study was conducted to see if suckling lambs would be benefited by large vitamin doses. Lamb numbers were too small to be conclusive in this experiment but it gave indications that under certain climatic conditions lambs may increase growth rate by the addition of a vitamin D supplement. Virtually no information is available on this subject for any area in the United States.

Eighteen purebred single Rambouillet lambs born between the third and sixteenth of December were used. These lambs were divided into two equal groups. Group A was treated with 900,000 international units of vitamin D₃ whereas group B was left untreated. From the beginning of the experiment, December 8, the lambs were weighed at two week intervals until the end of the study, March 16.

Treated lambs outgained the controls by an average of four pounds per lamb during the two week interval after the initial dosage of 300,000 international units of vitamin D. This was the widest range between the two groups at any of the two week weight periods. The treated lambs outgained the controls during six of the seven weigh periods. It was at the last weighing period that the controls gained an average of 11.5 pounds per lamb to only 9.4 pounds per lamb for the treated lambs. It appeared likely that the controls would catch up in weight with the treated lambs had this study been continued over a longer period of time.

This study gave only an indication that vitamin D supplements may possibly have beneficial effects on suckling lambs. Further work involving larger numbers of lambs is necessary before any definite conclusions can be drawn.