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THE EFFECT OF THYROXINE ON THE ROMNEY TWO-TOOTH

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WHILE IT HAS BEEN KNOWN for a long time that secretions of the thyroid gland play a large part in the growth and development of all surface structures such as hair, feathers and wool, it is only recently that the possibilities of stimulating wool growth on a commercial scale by the use of implants of *l*-thyroxine have been investigated. Hart (1957) found increases of up to 15% in the greasy fleece weights of mixed-aged Romney ewes which were subcutaneously implanted with 60 mg of *l*-thyroxine. No decrease in fertility of the mature ewes used in these trials was found when thyroxine implants of 60 to 90 mg were given within a few weeks of mating.

This paper records the first year's results of an experiment designed to provide a detailed lifetime study of the effect of annual thyroxine implantations on wool growth and productivity of Romney ewes. A secondary aim was to produce wool suitable for a manufacturing trial so that the effect of thyroxine on the manufacturing performance of the wool could be investigated.

The general methods and reproductive performance of the ewes are discussed first, followed by data on the wool response to the thyroxine implantation.

Effect on the Ewe

Sheep. From a line of 305 Romney two-tooth ewes 206 were selected for uniform wool type of bulk 48-50s count. These were then divided into two groups by restricted randomization on a weight basis.

Implantation. One group of 103 ewes was subcutaneously implanted in the shoulder region with 90 mg (three 30 mg tablets) of *l*-thyroxine on 23 March, 1956.

BODY WEIGHT

To gauge the effect of the thyroxine implantation the ewes were weighed 4, 12, 20 and 38 days after the implantation and

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monthly thereafter for the remainder of the trial period. A two-hour fast preceded each weighing.

The mean weights of the two groups are given in Fig. 1 and show a drop in liveweight of the treated group of 5.4 lb relative to the control in the 12 days following implantation, increasing to a maximum of 8.7 lb after 75 days. This weight differential was maintained up to lambing and it was not till the November weighing that the treated and control groups were similar.

Feeding. The determination of field responses implies the acceptance of seasonal conditions normally found in farm practice. The ewes were run on the Invermay Research Station which is situated at the head of the Taieri plain about 10 miles west of Dunedin. An exceptionally dry summer was relieved by rain in early April so that for two weeks following implantation when the boxed groups were grazing stubbles there was a low plane of feeding.

As shown in Fig. 1, both groups of ewes put on weight rapidly after the rain when they were grazing lucerne regrowth followed by young grass. By early May the flock was grazing fully recovered old pasture, but as they were observed to be unsettled on this feed they were moved in succession over four paddocks of less forward feed. A small loss in body weight was associated with this period. Feeding of lucerne hay commenced at the beginning of June. Swede turnip crop failures prolonged hay feeding until early August when a short daily period of turnip feeding was supplemented by restricted access to saved grass and continued hay feeding. This arrested falling body weights until lambing started on spring grass during the first week in September.

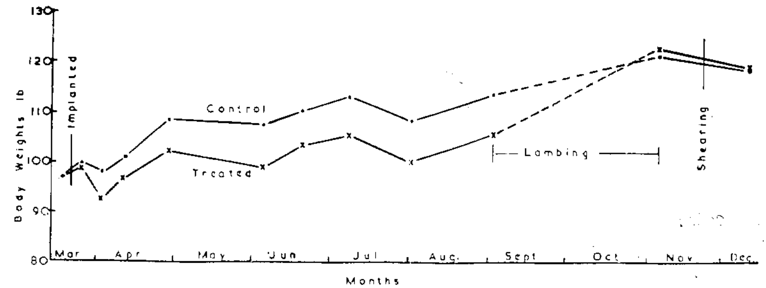

Fig. 1: Body weights, 1956.

The stock maintained satisfactory health in the experimental period, the mortality rate of 4 to 5% being typical of local conditions. One ewe in each group died of pregnancy toxaemia; the cause of the other deaths is not known.

Reproductive Performance

Four Southdown rams were put out with the boxed groups on 12 April, that is, 20 days after implantation, and removed 88 days later. At joining, the ewes were on an improved level of feeding and both groups increased in liveweight by about 7 lb in the first three weeks of mating. Tupping commenced immediately and the first birth was recorded 146 days after joining.

The reproductive performance of the two groups is summarized in Table 1.

Table 1: Lambing Performance

	Treated	Control
Ewes mated	103	103
Ewes at lambing	100	98
Total lambs born	88	108
Mortality to tailing	9	12
Ewes bearing singles	68	74
Ewes bearing twins	10	17
Barren	18*	5
No record	4	2

*$P < .01$

Evidence of a reproductive upset is shown by the significantly higher incidence of barrenness and a lower twinning rate in the treated ewes, which resulted in an overall reduction of 19 lambs per 100 ewes mated. The increased barrenness contributed the greater proportion of the total loss. Comparable mortalities at lambing and prior to tailing maintained the unfavourable difference in the effective lamb crop.

The state of pregnancy in the eight ewes that died prior to lambing has little effect on this result. Of three treated ewes one carried a single lamb, one was barren and the third was not recorded. Of five control ewes one carried a single lamb, two died early in the mating season and two were not recorded.

Associated with this reproductive upset the pattern of lambing as given in Fig. 2 shows that there was a delay in the rate of successful conceptions in the treated group. Although both groups started lambing at the same time and were comparable for some five days, thereafter the lambing rate of the

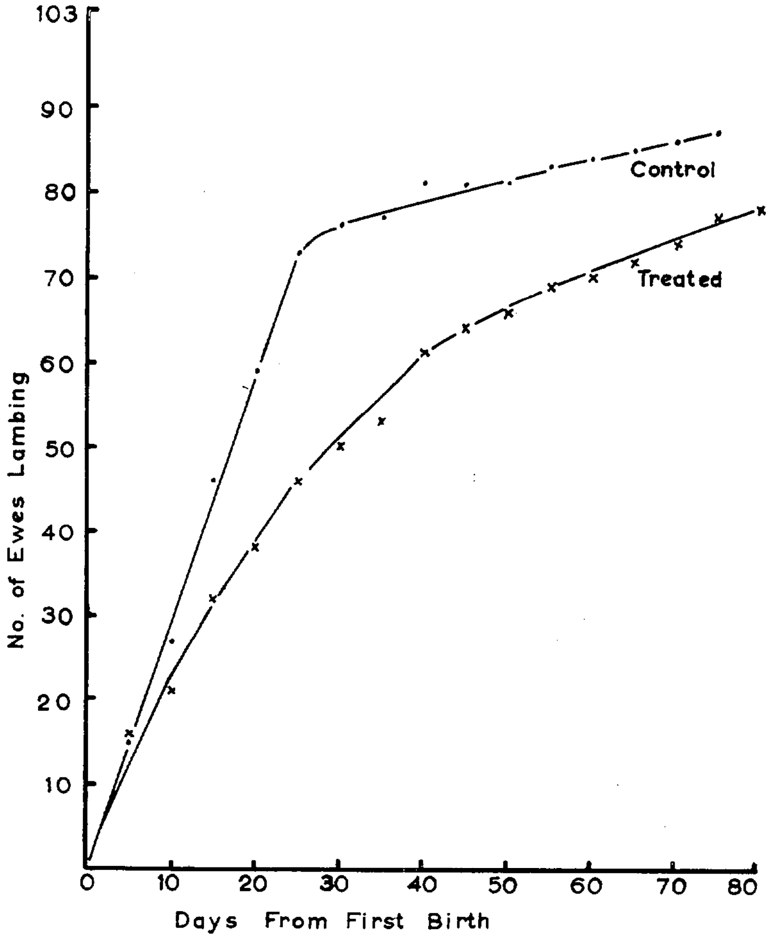

Fig. 2: Distribution of lambing.

treated group was retarded. After 34 days of lambing, representing two oestrus cycles, 53 treated ewes had lambed compared with 77 in the control group.

Table 2 shows that the mean lambing date for all ewes was delayed some 8.5 days, single and twin births being delayed 6 and 25 days respectively. The maximum difference of 30 in the number of ewes lambed, 46 treated and 76 control, occurred on the 26th day after the first birth.

As detailed observations of tupping were not made, the behaviour of the groups in oestrus can be inferred only from

TABLE 2: MEAN LAMBING DAY

	Days from First Birth				Diff.	
	n	Treated	*n*	Control	(Days)	*P*
All births	78	26.4	87	18.0	8.4	$<.01$
Single births	68	24.0	70	18.3	5.7	$<.1$
Twin births	10	42.2	17	17.1	25.1	$<.01$

the lambing records. The pattern of successful matings is, however, consistent with a partial suppression of oestrus induced by the treatment, although failure to implant the ovum or early death of the embyro cannot be excluded.

As the rams were with the ewes for a relatively long period (88 days), permitting five complete oestrous cycles, the higher level of barrenness of the treated group could be attributed to treatment effects persisting beyond the tupping period. As eight ewes in this group were settled in the last 17 days of the tupping period further conceptions could reasonably have been expected before the return to anoestrum.

Slow emergence from such effects can be seen particularly clearly in the distribution of twin births. Sixteen of the 17 sets of control twins were born within 22 days of the first birth whereas only three of ten treated sets were born in this period, the remainder being spread relatively uniformly over the rest of the lambing period. The treatment has thus reduced the number of multiple ovulations in the first few weeks of mating.

Although Hart (1957) presents data for mixed-age Romney ewes under varying conditions in which the date of implantation was no later than the beginning of March, its relation to time of mating was not stated. The timing of treatment in the present trial appears to have been critical, possibly because of the age of the sheep.

As much emphasis in recorded work has been placed on the effects of the hypothyroid state on fertility, thyroid medication has mainly been corrective. Careful augmenting of normal levels might possibly be expected to increase fertility if normality was clearly understood in terms of age, breed, season and relationship to other endocrinological processes.

GROWTH RATE OF LAMBS

Lambs were weighed at birth, at six weeks, and then at monthly intervals until weaning on 9 January. Mean birth weights of single lambs were similar—treated 9.21 lb and control 9.06 lb. No difference in lamb vigour or viability was observed.

Because of the variation in distribution of lambing dates and the consequent difference in age structure between groups, liveweight gains from birth to weaning are expressed in lb/ day/period calculated from the mean lambing date of each group.

Table 3 shows the close conformity of liveweight gains of single lambs in both groups to weaning. Because of the shorter average period from birth to weaning in the treated group, however, the total liveweight gain was 2 lb lower than the control. The possibility that thyroxine implanted prior to mating might stimulate lactation is not supported by lamb growth data. Twin lambs in particular gave no evidence of a lactation response, but insufficient twin pairs were produced for valid comparisons to be made, especially in view of the difference of about four weeks in mean lambing date between the twin births in each group.

TABLE 3: LIVEWEIGHT GAIN OF LAMBS (LB/DAY) (SINGLES ONLY)

Group	No.	Birth Wt.	Weeks from mean birth date 0-6	6-11	11-15	0-15
Control	62	9.06	0.563	0.399	0.257	0.433
Treated	50	9.21	0.564	0.406	0.243	0.428
Significance	—	n.s.	n.s.	n.s.	n.s.	n.s.

Assuming the first six weeks of lamb growth to be a measure of milk yield, it is concluded that no thyroxine activity due to the implantation persisted into the lactation period. As the wool response was virtually finished by July, lactation effects were improbable.

Effect on Wool Growth

EXPERIMENTAL

Wool Sampling. The ewes had been shorn as hoggets on 10-11 November, 1955.

On the day preceding the thyroxine implantation, a wool sample was clipped from a measured area of about 10 cm square from the mid-side position of each ewe. Samples were clipped from the same area at four-monthly intervals, that is, in March, July and November, for the remainder of the trial. In November, a sample of 12 months' growth was clipped from a similar measured area on the mid-side position on the opposite side of each ewe.

Wool Sample Measurement. The following six measurements were made on all the four-month and 12-month samples: conditioned greasy weight per 100 sq.cm, clean oven-dry weight per 100 sq.cm, yield at 16% regain, unstretched staple length, mean fibre diameter (airflow method), and the number of crimps per inch.

The greasy wool samples were conditioned for at least 24 hours at 68°F and 65% R.H. before weighing; about half of the sample was then weighed off and scoured in detergent and bicarbonate, dried to a low regain and then conditioned for at least 24 hours at 68°F and 65% R.H. before being re-weighed. Sub-samples were then oven-dried from which the yield at 16% regain and the production of oven-dry wool per 100 sq.cm was calculated.

The unstretched staple length was measured on five staples from each sample and the number of crimps per inch was then measured on the same staples. The crimp of the four-month samples was measured on the butt two-thirds of the staples by using a crimp wheel. The 12-month samples were placed on thin paper on a light box, and the peaks of the crimps marked on the paper from which the numbers of crimps per inch were calculated. Fibre diameter was measured on an airflow apparatus using the conditioned scoured samples, the mean of two readings on each of two 2 g samples being used.

Staple strength measurements were made on one staple from each of the 12-month samples. The butt ¾ in. of the staple was held between leather faced clamps, a second pair of clamps was then placed 2½ in. higher up the staple. The staples were broken on a yarn strength tester to which a device for recording the breaking curve was attached. After breaking, the wool was cut from between the clamps, cleaned with petroleum ether and warm water, dried to a low regain, then conditioned at 68°F and 65% R.H. for at least 24 hours before weighing. The staple strength was then calculated as (1) the total work required to break the staple in cm.lb/g and (2) the maximum breaking load in lb/g of clean wool.

Shearing. The sheep were shorn on 23 November, three days after the November sampling. Fleece weights were recorded, excluding bellies and board locks. The fleeces were graded for count number, style and faults.

Wool Response

As found by Hart (1957), there was a marked stimulation of wool growth following the thyroxine implantation.

TABLE 4: PERCENTAGE DIFFERENCES OF TREATED FROM CONTROL GROUP

	March-July Sample %	12-month Sample %	Total of Three 4-month Samples %
Conditioned greasy weight/100 sq.cm	+11.7*	+3.6	+4.6
Clean oven-dry weight/100 sq.cm	+10.3*	+5.1†	+4.4
Yield (actual differences)	— 1.1	+1.2†	—0.1 (1)
Staple length	+12.7*	+6.5*	+5.0
Fibre diameter	— 2.0†	—1.0	—1.2 (2)
Crimps/inch	+ 5.5†	—2.9	+3.3 (3)

*$P < .01$
†$P < .05$
(1) Greasy weight corrected.
(2) Oven-dry weight corrected.
(3) Length corrected.

Table 4 shows the percentage increase or decrease of the treated as compared with the control group for:

(a) The four-month period immediately following implantation *i.e.*, from March to July.

(b) The 12-month sample, clipped in November.

(c) The totals or means of the three four-month samples. The means of the three four-month samples for yield, fibre diameter and number of crimps per inch were corrected on the basis of the individual four-month greasy weights, oven-dry weights, and staple lengths respectively.

In the four-month period following thyroxine implantation there were large increases, significant at the 1% level, in greasy and clean wool production and in staple length in the treated group, accompanied by a small though significant decrease in diameter and a corresponding increase in the number of crimps per inch.

In the succeeding four-month period from July to November, wool production in both groups was very similar with a slight increase of from 2 to 4% in favour of the treated group for all the sample measurements with the exception of fibre diameter, which was the same for both groups.

As production of greasy wool in the control group for the three periods, November-March, March-July, and July-November was 47, 29 and 24% respectively of the total year's production, the relatively large increase from March to July and the slight increase from July to November, affected only half the year's production. The combined effect therefore represents only a small increase on the total year's production.

As shown in Table 4, only the increases in staple length and oven-dry wool are significant in the samples of 12 months' growth.

The increase in yield of 1.2% is of the expected order for a 5% increase in clean wool production. This indicates that the increased wool growth was of wool substance only and that there was no increased secretion of grease and suint. However, as there was no increase in yield in the March-July sample, the effect of thyroxine on grease and suint secretion is not clear, especially in view of the findings of Marston and Peirce (1932) that there was an increase in yield following thyroidectomy. While the mean diameter of the 12-month treated samples was slightly smaller than that of the control group, no increase in crimps per inch was found.

In general the differences in production shown by the totals of the three four-month samples were equivalent to the differences found between the 12-month samples.

Shearing Data. The greasy fleece weights less bellies and board locks are recorded in Table 5. The increase in wool production of the treated group of 3.6% ($P<0.05$) is the same as that found for the 12-month samples. In the large groups of ewes which bore and reared a single lamb, the mean fleece weights are almost identical. The major increases in fleece weight are in the groups of barren ewes and the ewes which had twins and reared either twin or single lambs.

TABLE 5: GREASY FLEECE WEIGHTS (LB)

	n	Control	*n*	Treated	Diff.
All ewes	98	9.68	100	10.03	0.35†
Ewes bearing singles*	73	9.81	65	9.83	0.02
Ewes bearing twins*	17	9.17	9	10.28	1.11†
Barren ewes	5	9.90	18	10.54	0.64
Others	3	9.10	8	10.36	1.26

*Lactating ewes only.
†$P<.05$.

No difference was found in either count number, style grading, or the number of cotted fleeces, between the two groups. Almost all the fleeces in both groups were tender and had poor mushy backs. On regrading and binning in the woolstore, no difference between the two groups was noted by an experienced wool classer.

Staple Strength. It was noted at shearing that most of the fleeces had a tender region in the staple about an inch above the butt. It is not surprising, therefore, that the work and breaking load figures given in Table 6 are comparatively low.

TABLE 6: STAPLE STRENGTH OF 12-MONTH SAMPLES (BREAKING LENGTH 2.5 IN.)

	Work to Break, cm.lb/g				
	n	Control	n	Treated	P
All ewes	98	232.2	100	270.8	$<.01$
Wet ewes	90	232.6	74	263.1	$<.05$
Barren ewes	5	234.8	18	276.3	n.s.
	Breaking Load, lb/g				
	n	Control	n	Treated	P
All ewes	98	51.4	100	61.7	$<.01$
Wet ewes	90	51.4	74	60.0	$<.05$
Barren ewes	5	58.8	18	63.8	n.s.

The work to break and breaking load figures of the treated group for all ewes are respectively 17% and 20% higher than those of the control group. This increase is significant for the ewes which were pregnant and lactating, but not for the small number of barren ewes.

The region in which the staples broke would largely be grown during the period from July to October, indicating that the effect of thyroxine had not completely finished by the time of the July sampling. It is interesting to note in the treated group, where there were a considerable number of barren ewes, that there is very little difference between the staple strengths of the wet and the barren ewes, indicating that the part that pregnancy and lactation play in causing 'break' in wool may be over-estimated.

Wool Response and Loss in Body Weight. It might be expected that those sheep on which the thyroxine implantation had most effect as measured by loss in body weight following implantation would show the greatest wool response. The wool response of individual sheep was measured by the March-July production of oven-dry wool expressed as a percentage of the pre-implantation period from November to March. The correlation of the oven-dry wool production in the control group for the two periods was highly significant, $r = 0.748$.

The results show only a trend, indicating that those sheep which lost the most weight had the best wool response, while in the period 4-30 April, when the treated group increased in body weight by 10 lb, those sheep which put on least weight had the best wool response.

A project designed specifically to test this relationship might well show a direct bearing between loss in body weight and wool response to thyroxine implantation, although Labban

(1957) found quite large wool responses with no accompanying weight loss.

Discussion of Wool Response

Recent work by Ferguson *et al.* (1956) has shown that in lambs the thyroxine requirements for wool growth and secondary follicle maturation are greater than those for general body growth. Data on blood thyroxine levels and on the relative demands of wool growth and other body functions in the Romney two-tooth are not available, nor are data on the rate at which the thyroxine implant enters the blood stream and is utilized by the ewe. Such data would be invaluable in interpreting wool responses due to thyroxine implantations.

The thyroxine response is one of fibre length with no large change in diameter, in agreement with Hart (1957) and Labban (1957). Similarly, Marston and Peirce (1932) found that thyroidectomy had no appreciable effect on diameter, although it did increase yield and decrease total wool production.

In the normal seasonal cycle of wool growth of Romney ewes on the Taieri Plain, it has been found that the time of maximum (or minimum) length growth precedes that of maximum (or minimum) diameter growth by about two months. The results of this trial confirm this observation, suggesting that, depending upon the time of thyroxine implantation, differential stimulation of length compared with diameter changes could be brought about.

Cortical cell measurements and estimates of the degree of keratinization would be necessary to ascertain if it is the rate of cell division in the papilla which is increased or if it is only an increase in individual cell length.

While no manufacturing trials have so far been carried out, the results of this trial indicate that the thyroxine group wool should process as will as if not better than that of the control group. The extra staple length and the increase in staple strength should result in less fibre breakage during carding and combing, with a consequent decrease in noil production and an increase in yarn strength. The small decrease in fibre diameter which occurred at a time when diameter is near its seasonal maximum is no disadvantage, while recent work has shown that increased crimp is a highly desirable feature from the point of view of both processing and the final cloth.

The major fault with New Zealand wool is the very high proportion of fleeces which are tender or form a break about lambing time. Thyroxine implantation just prior to parturition should, because of its effect on staple strength, decrease the severity of the break and also possibly stimulate milk production in the ewe.

A considerable amount of additional data is necessary before a complete picture can be drawn of the effect of thyroxine on the Romney two-tooth ewe. Any individual trial is limited to one environment and one season, and as a consequence these results may not show a typical response.

As about 50% of the annual wool production is grown in the summer months, a larger wool response might be found from implantations in early- or mid-summer, when seasonal wool growth is approaching its maximum. In this case the effects of the implant should have worn off by tupping time.

Summary

The implantation of Romney two-tooth ewes with 90 mg of *l*-thyroxine 20 days before mating resulted in a delay in the rate of conception of the treated sheep and an increase in the proportion of barren ewes. No effect was found on the growth rate of the lambs.

In the four-month period following implantation, there were considerable increases in greasy and clean wool production, staple length and number of crimps per inch, while there was a slight decrease in fibre diameter.

An increase of 3.6% was found in greasy fleece weight, while no difference in style grading or the number of faulty fleeces was noted. The staple strength of the treated group was about 20% above that of the controls.

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DISCUSSION

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