The Photoperiodic and Hormone Response of Wool Growth in Sheep

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IT is now two years since the first report of progress in this field was made to the Society in a joint paper given by Coop and Hart (1953). Much has been accomplished since then and the purpose of this paper is to report further on some aspects of this work.

Materials and Methods.

All sheep used in these experiments have been obtained from the same flock in the College, and have been housed in adjacent rooms and pens in the same building.

Feeding of all groups has been at exactly the same level per day. It consisted of a standardised daily ration of concentrates fed in pelleted form at such a level as to maintain the body weight of the control animals as near constant as was possible, throughout the year.

Weighing of all animals has been carried out regularly at not less than weekly intervals, and during critical periods, daily, in order to establish specific effects.

The photoperiodic rhythms were supplied by housing the sheep in two light-proof rooms, the necessary artificial lighting being obtained from ordinary gas filled filament lamps of such a number and wattage as to ensure that no portion of either room had a lower light intensity than 5 foot candles at the 18 inch level.

The hoods for the hooded group were made from a triple thickness of blackout material fashioned into a rough mask which could be pinned on to the sheep's face and neck wool in such a way as to completely obscure the eyes but still leave the muzzle free for feeding and drinking.

Samples of wool were clipped every month from a 10 c.m. square area of skin on the middle of the right hand side of the body, exactly the same area being clipped on every occasion. This was made possible by defining the area with tattoo marks in the skin. The wool samples thus obtained were then weighed and measured in the greasy state, scoured, and dried to a known moisture content, re-weighed and corrected for moisure and time (30.4 days). The actual weight of pure wool produced was thus obtained for each animal. Because the maximum rate of wool growth occurs during the summer, all sheep are subjected, prior to their experimental treatments to uniformity trials during the December, January, February period on the standard ration. Each animal's wool production over this period is measured and used to calculate a maximum production base line figure, to which all that animal's subsequent production either as experimental or control can be related. This means that apart from being able to make valid comparisons between groups and treatments, each animal can also be used, in a measure, as its own control. All the graphs plotted and shown in the figs. 1-5 have been done on this basis.

Results and Discussion.

A. Photoperiodicity Experiments.

The increased production of wool as the result of controlled light-dark rhythms has been demonstrated, Hart (1952), but there have been some doubts as to the actual initiatory factor responsible for inducing these photoperiodic responses. Yeates (1949) suggests that it is the change from an increasing plane of light to a decreasing plane

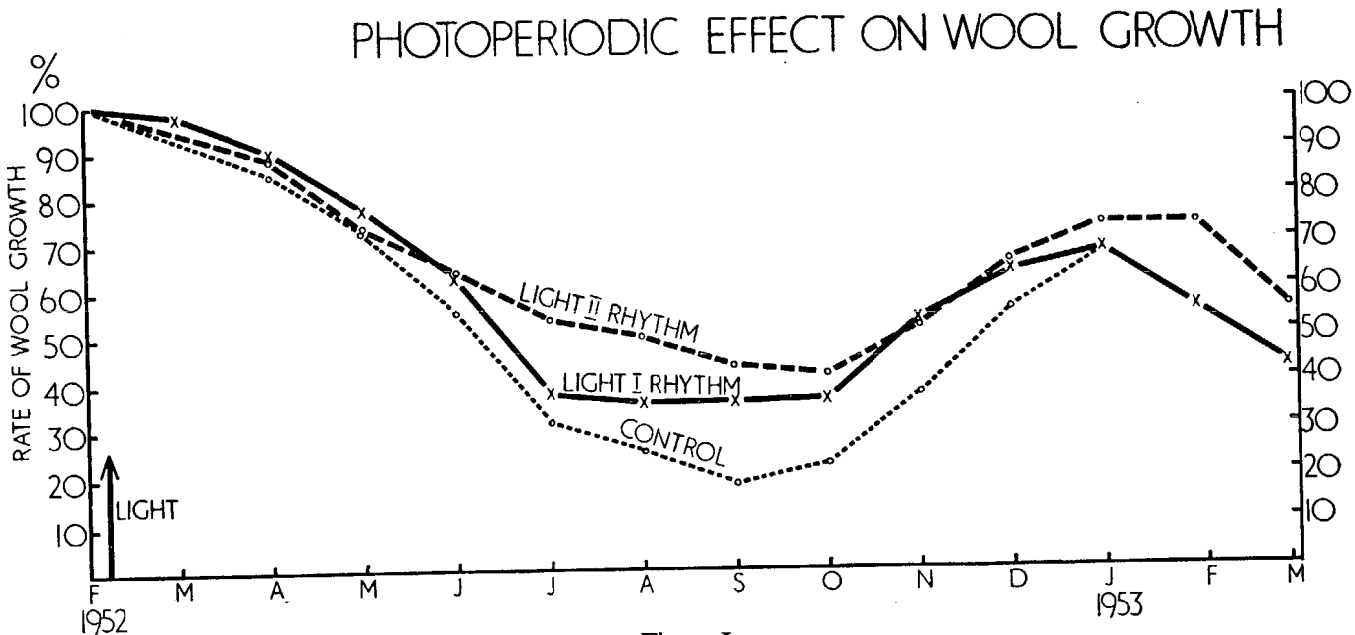
PHOTOPERIODIC EFFECT ON WOOL GROWTH
%
RATE OF WOOL GROWTH
100
90
80
70
60
50
40
30
20
10
LIGHT
LIGHT II RHYTHM
LIGHT I RHYTHM
CONTROL
F
M
A
M
J
J
A
S
O
N
D
J
F
M
1952
1953

Figure I.

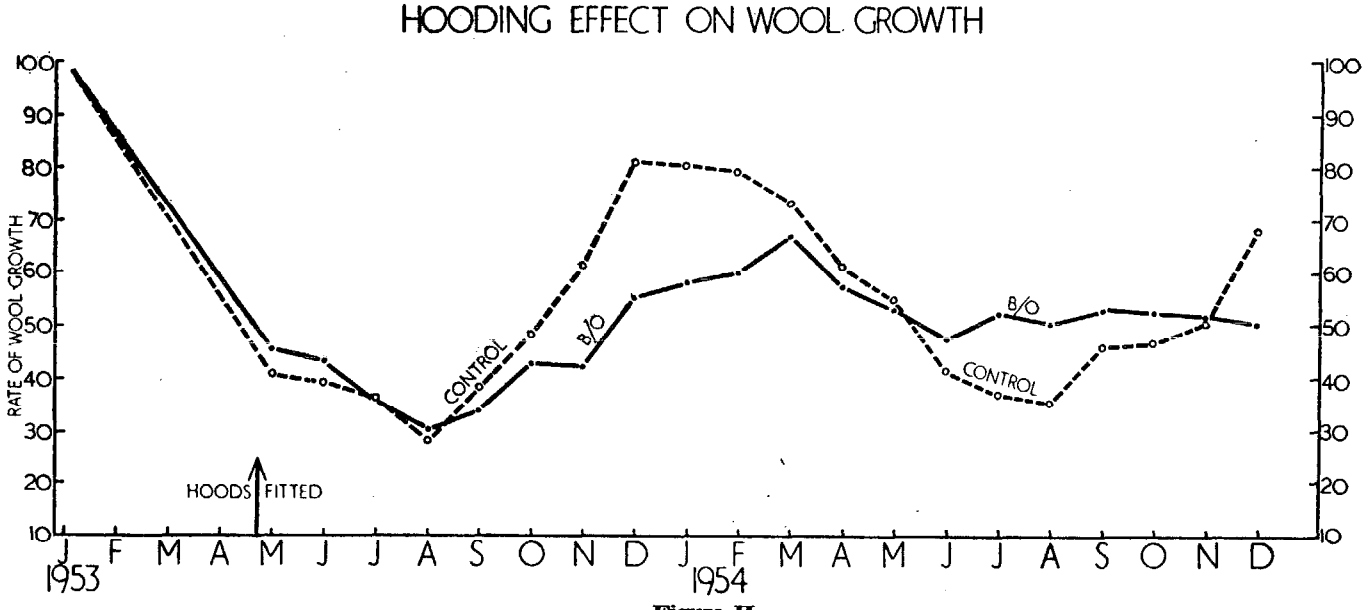
HOODING EFFECT ON WOOL GROWTH
RATE OF WOOL GROWTH
100
90
80
70
60
50
40
30
20
10
HOODS FITTED
CONTROL
B/O
CONTROL
B/O
J F M A M J J A S O N D J F M A M J J A S O N D
1953
1954

Figure II.

which is the responsible factor in sheep. However, in view of the responses which can be obtained from a fixed two to one ratio of dark to light rhythm there appears to be some doubt about this hypothesis. The "contrast sensitive" theory seemed a possibility and in February of 1952 two groups of not less than three standardised ewes per group were started, one on a Light I Rhythm of 8 hours light—16 hours dark and the other on Light II Rhythm of 2 hours Light—4 hours Dark.

The essential features to note here are that

1. in both groups the same total number of light and dark hours obtain in a 24-hour cycle.
2. The 2 : 1 ration is maintained.
3. They are fixed Rhythm sequences.
4. The number of contrast impulses received every 24-hour cycle is one in Light I and 4 in the Light II group.
   Results are shown in Figure 1 and clearly indicate:—
   (a) Both Light groups produce a significant increase in wool growth rate over the controls.
   (b) Light II group wool growth rate is significantly greater than Light I group throughout July, August and September.
   (c) The latent period of sensitization between initiation and and response has been accelerated by one month in favour of Light II over Light I group.

This evidence appears to strongly substantiate the "contrast sensitivity" theory reaction of the organ or organs in the animal body responsible for the expression of the photoperiodic stimuli in its various forms.

B. Hooded Sheep Experiment.

Having accepted the fact that some organ or organs must be responsible for the expression of this stimulus, the actual receptor mechanism together with the mode and path of the response excites considerable curiosity. The work of Thompson and Zuckerman (1953) indicates that the pituitary is responsible for initiating oestrus in light-treated ferrets but there appears to be a difference of opinion at the moment between these workers and Donovan and Harris (1954) as to the significance of the hypophyseal portal vessels forming a necessary part of the pathway.

Unfortunately no published work appears to have been done on the sheep in this direction so although it appears to be the obvious receptor mechanism, the eye required to be investigated first. Accordingly, three previously standardised ewes were hooded towards the end of April, 1953, and placed in a pen under the Light I rhythm, where they remain to-day.

The results from the hooded sheep are shown in Fig. II. It appears obvious that:—

(a) The hoods have effectively prevented any photoperiodic response.
(b) The characteristic sine-shaped curve of normal wool growth throughout the year appears to have been eliminated, and the animals have settled down to a steady rate of production showing little variation over the last eight months.
(c) The latent period of sensitization before there is any significant divergence from the controls is very similar to that of Light I group, i.e., about 5-6 months.

It might be suggested that the prevention of the reception of any photoperiodic stimulus has somehow resulted in the animal being "insulated" from the stimulus of the environmental factors affecting wool growth with the possible exception of nutrition, and as this remained at a constant level, likewise so did wool growth.

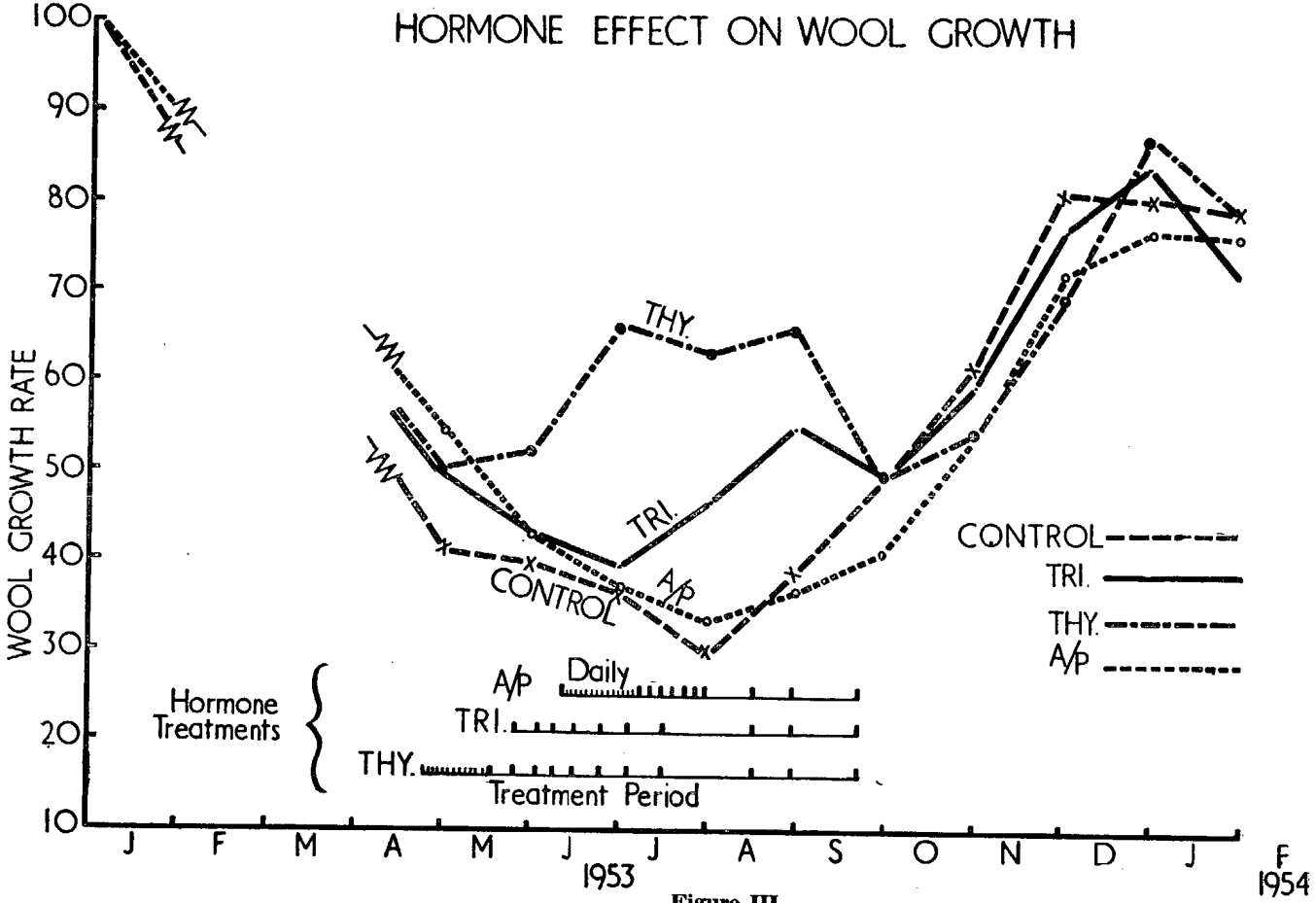
HORMONE EFFECT ON WOOL GROWTH
WOOL GROWTH RATE
100
90
80
70
60
50
40
30
20
10
THY.
TRI.
CONTROL
A/P
CONTROL
TRI.
THY.
A/P
Hormone Treatments
A/P Daily
TRI.
THY.
Treatment Period
J F M A M J J A S O N D J F
1953
1954

Figure III.

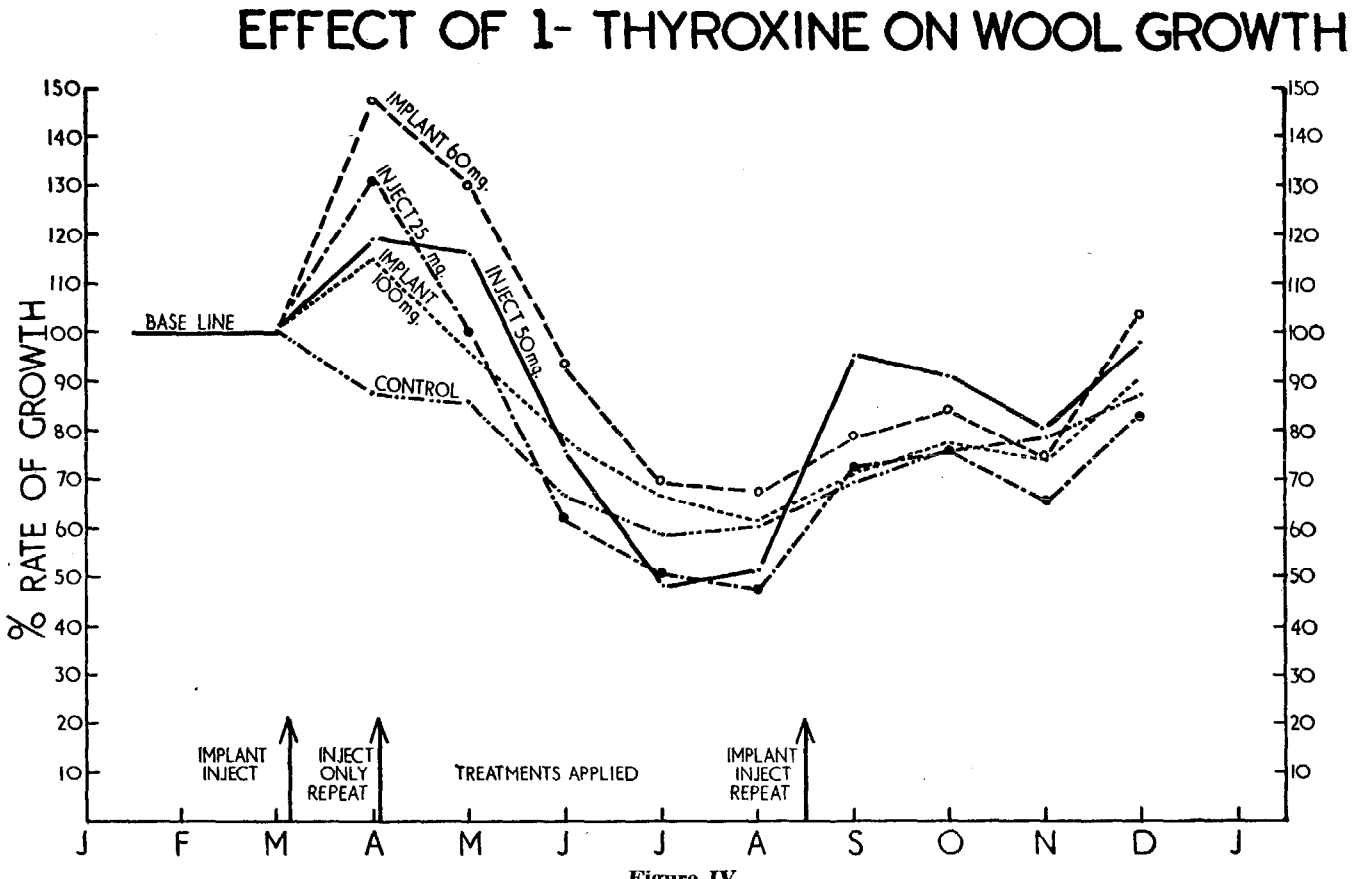
EFFECT OF 1- THYROXINE ON WOOL GROWTH
% RATE OF GROWTH
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
BASE LINE
IMPLANT 60 mg.
INJECT 25 mg.
IMPLANT 100 mg.
INJECT 50 mg.
CONTROL
IMPLANT INJECT
INJECT ONLY REPEAT
TREATMENTS APPLIED
IMPLANT INJECT REPEAT
J
F
M
A
M
J
J
A
S
O
N
D
J

Figure IV.

This suggestion is an interesting one because if it is the correct interpretation of the facts then it means we have eliminated any effect of temperature as well. However, having now defined the eye and its immediate surround as the receptor mechanism we reach another stage of the investigation.

C. Hormone Replacement Experiments.

Assuming the pituitary body to be the first centre of response to photoperiodic stimuli then the question arises: is this response a blanket one and are all the hormonal functions of the gland stimulated or is it specific in nature; and is only one section or cell type called into action.

As a preliminary, to this obviously extremely involved investigation, and in an attempt to work back from the increased rate of wool growth point, it was decided to test the effects of two thyroid type synthetic hormones which were fairly easily obtainable and a commercial extract of Anterior Pituitary.

In the winter of 1952 a small preliminary trial had been carried out using l-thyroxine. This had seemed promising, so three experimental groups were constituted together with one control group in 1953.

Hormone treatments consisted of (a) l-thyroxine injected subcutaneously as an equeous solution in thirteen 4 mg injections totalling 92 mg per ewe over the period.

(b) Tri-iodo-thyronine injected subcutaneously as an aqueous solution in ten 3 mg injections, totalling 30 mg per ewe over the period.

(c) Anterior lobe pituitary extract administered orally, totalling 92½ grains of desiccated substance for the period. A brief acocunt of this experiment has been given elsewhere. (Hart, 1954).

The results as shown in Fig. III were both significant and spectacular. But there are obvious disadvantages in the injection method and in 1954 another experiment was conducted involving some thirty-two sheep but using only one hormone l-thyroxine, administered in two forms at two different dose levels. both dry and pregnant ewes were used but in the interests of time we can deal only with the one set of results, namely, that of the dry sheep.

Five groups of four sheep previously standardised were constituted and treated as follows:—

Group I Control.
Group II 100 mg l-thyroxine implanted in pellet form subcutaneously.
Group III 60 mg l-thyroxine implanted in pellet form subcutaneously.
Group IV 25 mg l-thyroxine suspended in oil injected subcutaneously and repeat dose a month later.
Group V 50 mg l-thyroxine suspended in oil injected subcutaneously and repeat dose a month later.

The result shown in Fig. IV are once again both significant and spectacular over the four months following treatment.

The average percentage rate of increase of wool growth per month in Group III compared with the controls during this period amount to approximately 45% and on this basis the increased wool obtainable from one single implant might amount to 15% of the total twelve month production. The implications appear fairly obvious but to me these results have some other more interesting facets to which I should like to draw your attention in the hope of stimulating some helpful discussion. Unfortunately it is not possible to deal with them specifically in this paper.

1. There was, as expected, a loss of live weight in all the hormone treated groups, amounting to about 10 lb. live weight. This ability to remove weight from ewes during the summer and autumn without having to alter their nutritional status has its advantages.

2. The response from the 60 mg implants (Group III) in increased wool growth was significantly greater than that from the 100 mg implant (Group II) indicating possible threshold effect limitations.

3. The failure of the repeated implantations in August to have any immediate effect, whereas there appears to have been a response from the 50 mg injection (Group V).

Is this because the effects of the previous implants have not yet completely worn off or perhaps because the treatment was applied when the animals were entering a new physiological phase, having just passed from the winter phase, and whilst in an active physiological phase additional responses cannot be obtained.

4. It appears that the photoperiodic response in wool growth could be due to an increased thyrotrophic activity of the pituitary and not the growth hormone effect suggested recently by Ferguson (1954), whose responses may be accounted for by the thyrotrophic hormone contaminant which his Ox growth hormone extract contained.

Additional support to this hypothesis is adduced by the results from a group of ewes injected daily with 25 mg of Somatotrophin for a period of 18 days. This amount should have been sufficient to establish biological activity at least comparable with that found by Jordan and Shauffhausen in their lactation studies (1954). The results

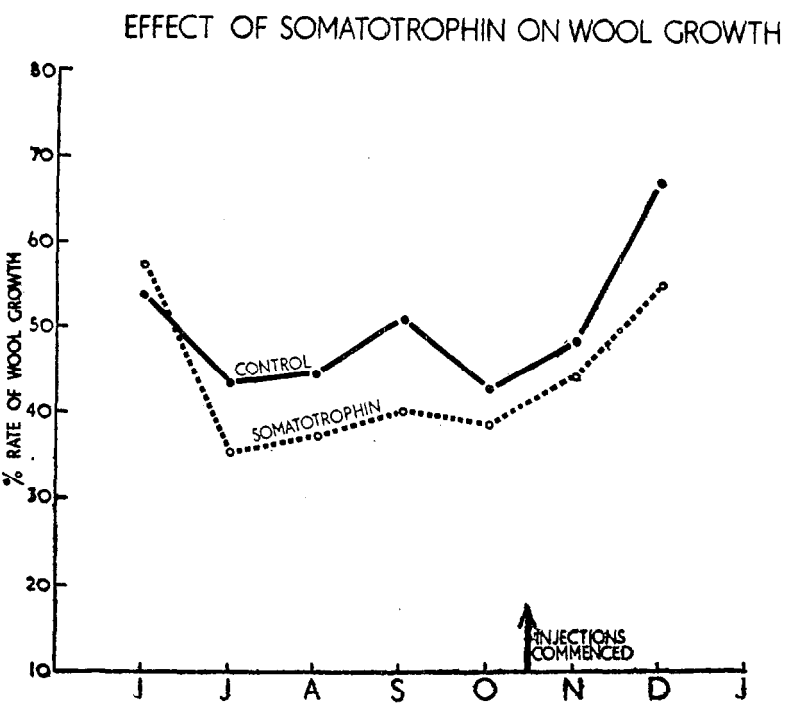

Figure V.

shown in Fig. V certainly give no indication of having had any effect on wool growth. It is too early yet to draw definite conclusions on this somatotrophin trial, for many reasons, one of which might be a masking effect which could be due to the "active physiological phase" hypothesis. On the other hand, this result could also indicate that this particular brand of somatotrophine is at least free of any thyrotrophic type of contaminant and is a fairly pure sample.

Mention was made earlier of the pregnant groups being subjected to the hormone treatment. This was done mainly to test out for any deleterious side effects on oestrus, conception rate, lambing rate and subsequent growth of the lambs, and lactation levels. For the present all that need be reported is that we have so far detected no measurable deleterious effect from l-thyroxine on any one of the above points.

It would appear from these experiments that we now have a hormone readily and reasonably available which, under certain conditions, is capable of bringing about substantial increases in the amount of wool grown by sheep.

ACKNOWLEDGMENTS:

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