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Environmental Factors Affecting Wool Growth

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THE economy of the Southern Dominions is to a considerable degree dependent on wool. Here in New Zealand we have had much evidence in recent years of the part that wool plays in our national life and income. It is a matter of some importance therefore to elucidate the fundamental factors which influence the growth of wool and to devise practical means for exploiting such knowledge to improve the production and quality of our clip.

In the past breeding has dominated the field. One has only to recall the evolution of the Australian Merino and to a lesser extent the New Zealand Romney to realise that breeding plays a most important part in determining wool production. In recent years research into the relationship of breeding and wool production has been concerned with two aspects—the search for rams of high wool merit by means of the progeny test and the measurement of the degree of inheritance of the many characteristics definable under the term wool quantity and quality. The latter aspect has demonstrated the low heritability of fleece weight and also, to a lesser extent, of fleece quality, or in other words, has shown that wool production is highly sensitive to environment. Environment is therefore of major importance in determining wool production and all aspects of its effect, both fundamental and practical, must be of interest to wool growers. This paper concerns itself with some of the recent developments in this field.

Of the many components of the term environment, nutrition has long been known to have a profound effect on wool growth. A large number of experiments and observations in many countries on these effects are listed in the literature. These have shown that extremes of feeding can increase or decrease fleece weight to a marked extent. Marston, for example, showed that within nutritional limits of twice maintenance and half maintenance the rate of wool growth was proportional to the level of feeding. Several years ago at Lincoln, McMahon fed sheep at widely differing levels of nutrition and found fleece weight to vary from 5-16lb. as a result of these treatments. Farmers are also aware that their wool clips vary considerably from year to year as a result of feed conditions. To take as an extreme case, the mean fleece weight of the whole 2000 sheep at th Ashley Dene farm of Lincoln College was as high as 10.8lb. in 1951 and as low as 7.6lb. in the following year, 1952. Good feeding besides increasing fleece weight also improves certain features of quality. Thus character is improved and the incidence of breaks and coting is reduced.

Taken all together it is clear, and it is well recognised by farmers and scientists alike, that nutrition is a most important factor in determining wool growth. So important is it that until the last two or three years nutrition had become more or less synonymous with environment and no attention paid to the other aspects of environment. Part of the cause of this situation was undoubtedly that most workers used annual fleece weight as a measure of wool production and did not split annual production into seasonal production. Those few who did attempt the latter unfortunately used staple length increase as a measure of production and this is not as variable as

weight change. And those who did measure seasonal production in terms of weight did not control or measure nutrition.

The first unequivocal demonstration that climatic factors also influenced wool growth was that of Ferguson, Carter and Hardy in Australia in 1949. They measured the weight of wool grown per month by clipping delineated areas of the sheep's skin at monthly intervals. They used dry Corriedale and Merino ewes fed a constant diet in stalls throughout the year. It was found that the wool grew fastest in summer and slowest in winter, giving a close correlation with mean temperature. In the Corriedales winter production was 73 per cent. of summer production, equivalent to 1 per cent. difference for each 1 F. degree of temperature difference. Ferguson, Carter and Hardy postulated that wool growth was affected by temperature through the mechanism of vasodilation whereby high temperatures caused greater circulation of blood to the skin and hence greater supply of nutrients to the wool follicles.

At Lincoln College we have been following up these observations and making an intensive study of seasonal wool production. The first experiment consisted of a grazing trial at Ashley Dene in which 24 wet Corriedale ewes split into four groups were maintained on pasture and supplementary feed from January 1950 until May 1952. The different groups were subjected to high and low planes of nutrition during either the dry, pregnancy or lactation periods. Wool was clipped from tattooed areas every month and the weight, length and count measured.

Fig I.

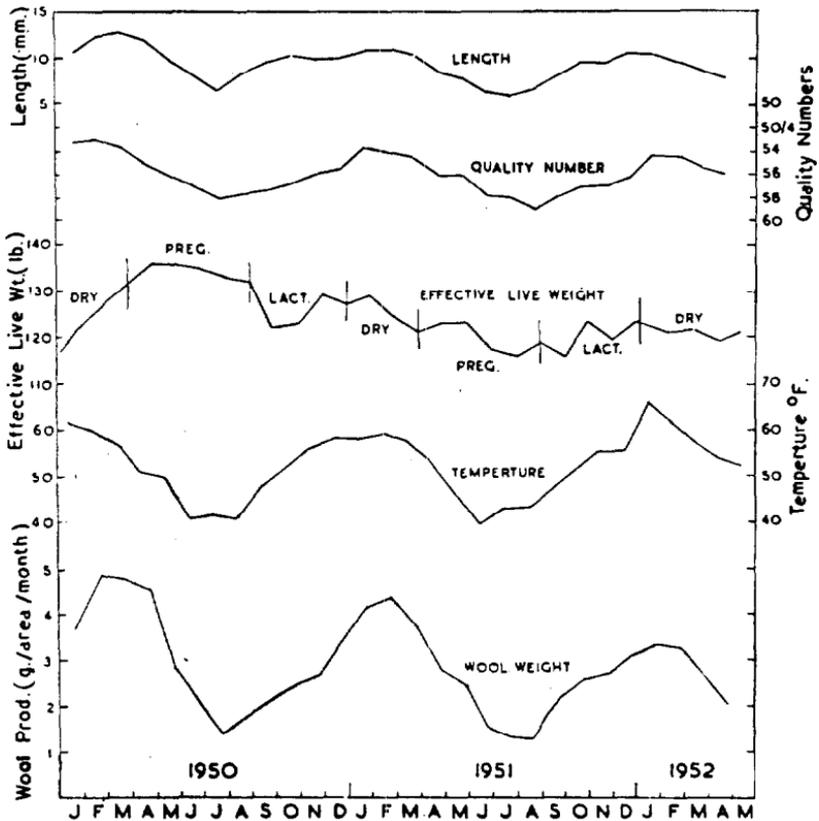


Fig. 1 gives the results obtained over the 2½ years. In this figure the mean of all ewes, irrespective of treatment, is given. Effective live weight, that is, actual live weight less deductions for the weight of wool carried at any month and the weight of the foetus during pregnancy, is taken as the index of nutritive status. The main feature of these experiments is the remarkable seasonal rhythm of wool growth, with maxima in February-March and minima in July. Mid-winter production is less than a third of the maximum summer production. The figure also shows that changes in wool weight are caused by sympathetic changes in both length and diameter of fibre. It can be seen too that the rhythm is not due to good nutrition in summer and poor nutrition in winter.

That these observations are not the result of using wet ewes only was proved by including groups of dry ewes and ewe hoggets with the wet ewes in 1951. These sheep gave rhythms essentially similar to those of the wet ewes, but with two important modifications. Firstly, winter production was not quite as low because there was no competition with pregnancy and secondly, maximum wool production occurred in October-November when the feed was best and when in this case there was no competition with lactation.

During the dry, pregnancy and lactation periods groups were kept on either high or low levels of feeding. It was found that wool production at any point or time could be raised or lowered by varying the amount of feed available. The most striking observation was that no matter how well the sheep were fed in winter they could nowhere approach the maximum summer production and could not in fact exceed the production of ewes being deliberately starved in summer and autumn. So strong was the seasonal nature of the wool growth rhythm that it required extremes of nutrition to nullify it.

In order to prove conclusively that the seasonal rhythm was not due to differences in amount and quality of the pasture resort was made to stall feeding trials. These were conducted throughout the whole of 1951 and 1952 using wet Corriedale ewes fed a ration of constant composition at rates which maintained the effective body weight of the ewes constant. They confirmed the existence of the wool growth rhythm previously shown in the grazing trials. Correlation with temperature was good, giving a difference of 3% in wool production per F. degree difference in temperature.

In the course of the stall feeding trials three ewes were kept in a room 13 F. degrees above the outside temperature during the four winter months. Contrary to expectation this treatment failed to increase wool growth and so does not confirm the theory of Ferguson, Carter and Hardy. This experiment requires to be repeated and on a larger scale, but at the moment all that can be said is that experimental evidence as is available indicates that temperature does not have a direct effect on rate of wool growth.

The next series of experiments were concerned with the effect of light-darkness rhythm on wool growth. They were initiated in 1951 by Mr. D. S. Hart and represent his contribution to this paper. The stall fed ewes just mentioned which were subjected to ordinary solar radiation acted as controls to a group which were fed the same ration but were subjected throughout the whole year to a constant daily rhythm of 8 hours' light and 16 darkness. The results of this experiment are given in Fig. II. It shows in the control group the seasonal rhythm of wool production already mentioned. The experimental group began to produce more wool than the control group in May and this continued until November by which time their production had returned to that of the controls. For most of this 6-months' period the experimental group grew wool at a rate of 30-40% greater

than the controls. At shearing the experimental ewes clipped 1½lb. more wool per sheep than the controls.

This experiment was repeated in 1952 and the observations made the previous year were fully confirmed except that now that the ewes had become conditioned to the treatment the response extended over nine months of the year. In 1952 an additional group was introduced, subjected to a daily ratio of 8 hours' light and 16 hours' darkness but split into four sequences of two hours' light and four hours' darkness. This group therefore received four light to darkness changes per day instead of one. This modification resulted in a still greater response to the light treatment in as far as the group exhibited increased wool growth compared with the ewes subjected to the first light treatment. This increase measured from autumn to mid-winter amounted to 20% more than the first light treatment.

It is clear from these experiments that the seasonal rhythm of length of daylight or darkness must be added to the list of environmental factors affecting wool production. In particular it is responsible for part of the low winter and spring wool growth since this is the period when the ewes subjected to the changing solar radiation produced less wool than those subjected to a constant light-darkness pattern. The mechanics by which light-darkness contrasts affect wool growth is not yet known, but presumably it operates through the anterior pituitary gland, as it is known that this body can be activated to produce other responses such as onset of the breeding season by similar light-darkness contrasts.

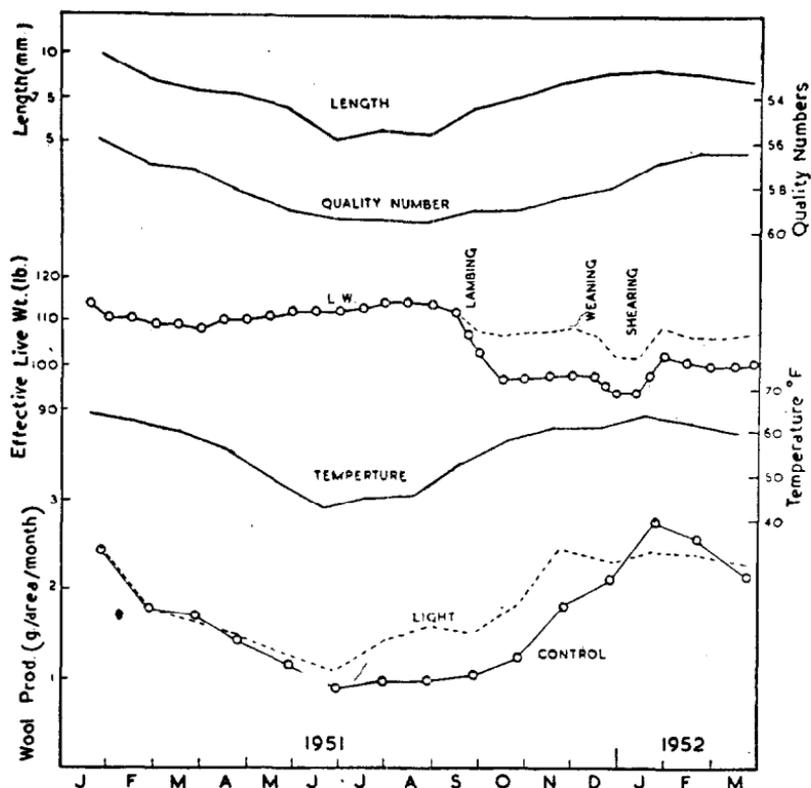
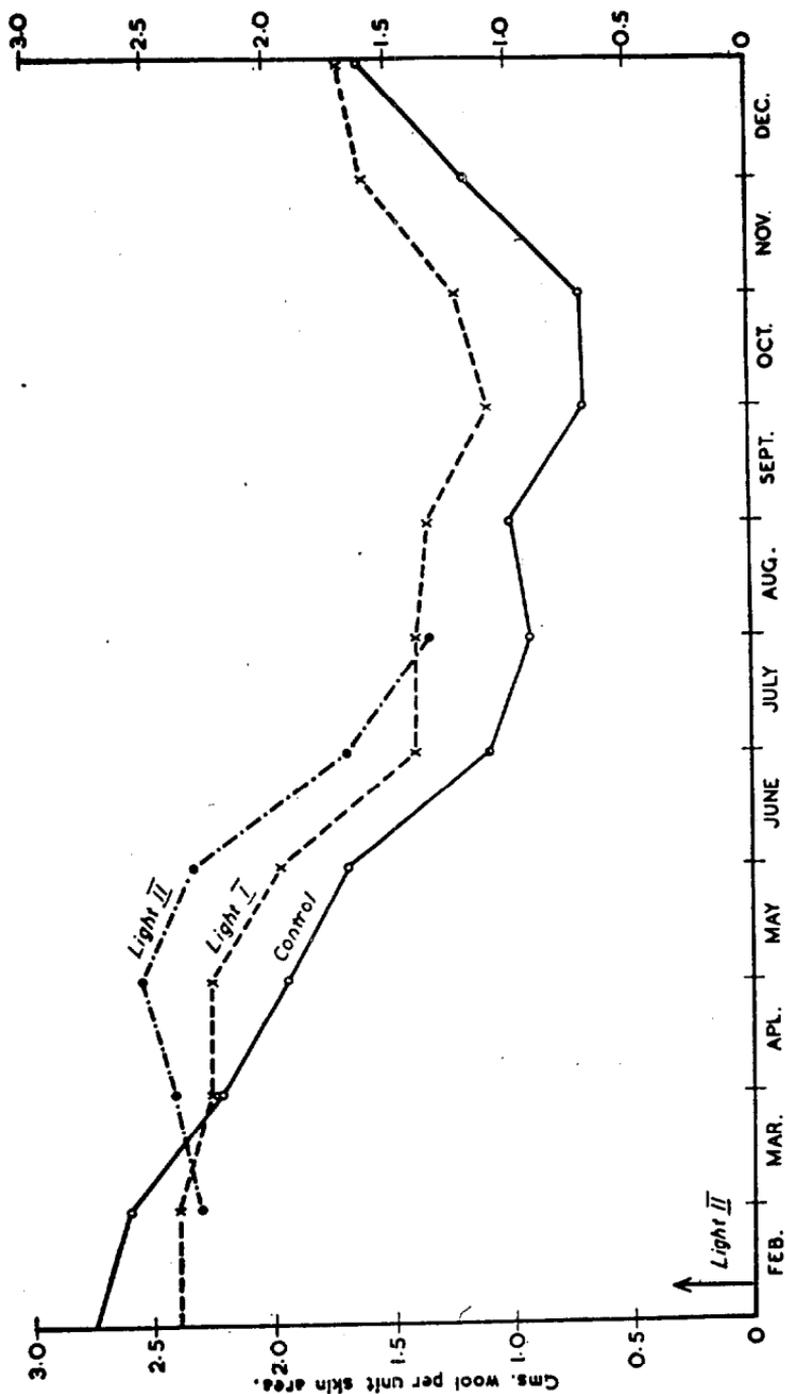


Fig II.

Monthly Wool Production

Fig III.



A further important observation from these "light" experiments is that even those ewes subjected to a constant light-darkness pattern throughout the whole year still exhibit a seasonal rhythm of high-summer, low-winter production, the ratio being about 2 : 1. Therefore seasonal light rhythm is not the only cause of low winter production and we must look for still more causes. Obviously since it is not nutrition it must in some way be connected with seasonal change. Although the wool growth rhythm correlates well with temperature the experimental evidence is against temperature per se being the cause. What we now suggest, although there is no direct evidence for it as yet, is that the wool growth rhythm results from the seasonal rhythm of temperature. It is known that seasonal temperature changes influence thyroxine output and it has recently been shown that thyroxine has an effect on wool growth. It could well be that a seasonal temperature operated rhythm of thyroxine, or, more likely, that of some other wool growth hormone is the cause.

Having thus shown that nutrition is far from being the only environmental factor affecting wool growth it seems desirable at such a conference as this to descend from the realm of fundamentals to the more practical considerations.

The light experiments would lead us to make a number of suggestions:—(1) the characteristics of wool growth are likely to be influenced by geographical latitude since this determines the intensity of the light-darkness rhythm and in general the greater the latitude the greater would be the difference between summer and winter production—other things being equal. (2) Any stud breeder desirous of putting an outstanding fleece on a ram could adopt a light treatment to advantage to himself but not to the purchaser of the ram. Temperature considerations suggest that sheep in localities with a low summer-winter range of mean temperature would produce wool at a more even rate and therefore of more even quality than those in areas with a large contrast in seasonal temperature. As season and climate are beyond the control of man, little practical use of the light and temperature effects can at present be made by farmers. We must wait until further fundamental work is performed on the mechanism of these effects, with the ultimate object that if they involve hormones such hormones may be extracted or synthesised and fed or injected into sheep to produce the desired increase in wool growth.

That brings us back to nutrition as the main environmental factor at present under human control. Since such spectacular increases in fleece weight can be obtained from improved feeding the first impression is that one should institute a programme of good feeding all the time. But it is here that one runs against a number of real difficulties. Firstly, wool is really a by-product of sheep farming, though an extremely valuable one, and secondly, in any case the most important thing is high wool production per acre and not high fleece weight per sheep. To give an example in the two years 1949 and 1952 at Ashley Dene feed conditions were somewhat comparable. In the first year we carried 1500 sheep averaging 11.4 lb. of wool and in the second 2000 sheep averaging 7.6 lb. of wool. The former were reasonably well fed and the latter were lucky to survive, yet wool production per acre was not much less in 1952 and most important of all we weaned 400 more lambs in 1952. A second point we have come against is this: We have found that good feeding during the winter increases fleece weight by 1-1½ lb. and improves the quality, but we cannot afford to implement the good winter feeding programme without reducing carrying capacity to the point where lamb and wool production per acre are reduced. Again in our flushing policy we deliberately put our ewes on short commons for about 6-8 weeks from weaning till flushing in order that they should respond to the flushing treatment. But this is at the very period when the potential of wool

growth is a maximum and we estimate that the cost of this policy in decreased wool production is upwards of £200 per 1000 ewes on present day prices.

These are merely some of the difficulties experienced in trying to improve wool production on a farm where many other factors have to be considered. It is clear, however, that if in the practice of farming every attempt to increase wool production is frustrated by some unforeseen disadvantage, at least in the field of fundamental wool research some progress has been made in the last few years.

ACKNOWLEDGMENT:

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Discussion

Mr. SINCLAIR: How does this tie up with your earlier work on high and low planes of nutrition?

Prof. COOP: This latest work shows that rate of growth of wool is approximately equally sensitive to nutrition at all times of the year. The earlier observation that fleece weight was influenced by nutrition to a greater extent during pregnancy than during lactation is nevertheless still true. Because of the delay between treatment and effect, the full effect during pregnancy, but only part of the full effect during lactation, is obtained in the fleece at shearing.

Mr. BONNER: What method of lighting did you use?

Mr. HART: 100 watt gas filled lamps sufficient in number to give an intensity of not less than four foot candles at the sheep's eye level.

Dr. JOHNS: Why did you use 8 hours of daylight and 16 hours of darkness?

Mr. HART: Previous work had shown this rhythm-ratio to be effective in stimulating the pituitary; for example the production of gonadotrophic hormones.

Dr. MELVILLE: Why was this ratio of light to dark used when it is known from field experience that there is more wool growth in the summer than in the winter?

Mr. HART: The experiment was designed to provide information on several factors other than wool growth, and in any case all the evidence suggests that the maximum wool growth in summer is not due to a stimulus received from the greater amount of daylight.

Dr. HAMILTON: Is it not possible that the rate of change from light to dark and vice-versa may be responsible for the difference in wool growth?

Mr. HART: This may be a contributing factor, in which case it is of minor importance as it is believed that the contrast between long-dark and short-light is the main initiating factor.

Mr. BARTON: Is the growth of wool on shaved areas of skin a true index of wool growth generally?

Prof. COOP: The method used was the generally accepted one for measuring rate of wool growth. All the tests that we have been able to devise show that it does give a true index of growth over the fleece as a whole.

Mr. CLARKE: Was the level of nutrition kept constant throughout the experiment? Were there any individuals in the groups that showed a straight-line pattern of wool growth? What amount of handling were the sheep subjected to?

Prof. COOP: The highly seasonal nature of rate of wool growth occurred in spite of the fact that the diet was kept constant from January until June when the demands of pregnancy and later lactation required that the amount of feed be increased to maintain a constant effective body weight. Every one of the 50-60 sheep on which measurements were made showed the typical rhythm of wool growth. The grazing sheep were yarded once a month and that was the only handling they received. The stall fed sheep were handled almost every day.

Dr. McMEEKAN: Why was the theory that temperature influences wool growth abandoned?

Prof. COOP: The theory of Ferguson, Carter and Hardy was based on low wool production in winter being due to low winter temperature and vice-versa. We had to abandon this theory because, while we also got low production in winter, raising the environmental temperature artificially for 3 months failed to increase wool production. We concluded that temperature per se does not influence wool growth but that the long term seasonal rhythm of temperature may do so.