Efficiency of Wool Production in a Semi-Arid Environment

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SUMMARY

There are areas in the semi-arid sheep belt with great between-year and between-season variation in pasture production.

It is difficult or impracticable to modify stocking rates according to the amount of pasture available. Generally a major difference between a good period and a bad period is that more pasture is wasted in the former.

If the amount of food consumed cannot be increased by raising the stocking rate during good periods, it may be increased only by raising food consumption per head. This may be attempted:

(i) Genetically; as by selection for clean wool weight per head, or
(ii) Environmentally; as by administration of thyroxine. Possible disadvantages of this method are discussed.

I. INTRODUCTION

The requirements of maximum production from animals on pastures have been discussed by Wallace (1959). The three essential requirements are repeated here.

(i) The pasture should provide a large amount of high quality feed.
(ii) The highest possible proportion of this feed should be consumed by animals.
(iii) Production systems should be adopted and livestock chosen so that the feed consumed is converted into animal products with the maximum possible efficiency.

We shall consider the bearing of each of these requirements on certain semi-arid areas of Australia’s sheep belt where sheep graze on unimproved pastures.

II. PASTURE PRODUCTION

(a) Effect of Annual Rainfall

Except in years of very high rainfall, annual rainfall is probably the limiting factor to total annual grass and herbage production in the semi-arid areas of Australia. Between-year variation in rainfall will therefore be followed by between-year variation in pasture production, both in growth of perennial plants and of ephemeral grasses and herbs.

In general, for stations with similar mean annual rainfalls, between-year variation is greater in the northern summer rainfall areas of the eastern sheep belt than in the southern areas which have a winter rainfall peak (Barkley 1931, Taylor 1951, Leeper 1960). There is a similar trend of lower variability as one moves westwards in the semi-arid sheep raising areas from southern New South Wales, through South Australia to Western Australia, again considering stations on a given isohyet.

Variability in mean annual rainfall, therefore, is greatest from western Queensland to north western New South Wales, and in the Western Australian sheep belt north of the Murchison River. In these areas the greatest between-year variation in pasture production will also be expected.

An illustration of this variation in both annual rainfall and pasture production is given in Figure I, which records quarterly measurements of the amount of dry matter available to sheep on a Mitchell grass pasture at “Gilruth Plains”, Cunnamulla, south-west Queensland, during the years 1941-1951 (Roe and Allen, 1945 and private communication). The pasture was grazed continuously at the rate of one sheep to 5 acres, and the quarterly clippings of pasture have been classified into inert material and identifiable grasses, herbs or legumes. Monthly rainfall figures are also plotted within the pasture growth periods in which they were recorded.

(b) Effect of Seasonal Rainfall Pattern

The seasonal rainfall pattern, plotted from mean falls for individual months, also varies greatly from one sheep-raising area to another within Australia (Bureau of Census and Statistics 1959). The extremes are a high summer peak at the northern end of the Queensland sheep belt, and a winter peak in the southern areas of New South Wales, South Australia and Western Australia, which becomes more prominent as one moves westward. In southern Queensland there is a summer peak with a secondary mid-winter peak, while in central western New South Wales the mean monthly rainfall is approximately uniform throughout the year.

Generally speaking, winter rain is more useful for plant growth than an equivalent amount of summer rain, because of lower winter evaporation. “Useful rain” may be measured by a ratio such as those involving precipitation and evaporation or precipitation and saturation deficit. The seasonal pattern of these ratios shows a similar geographic distribution to that of rainfall, but the winter peak appears farther north in Queensland and becomes steeper and higher in the southern areas of the Commonwealth as one goes west.

In addition to geographic differences in the seasonal pattern, between-year variation in the pattern at any one station is of importance in relation to pasture production. If there is a consistent summer rainfall peak, a summer flush in pasture growth can be anticipated. If there is a variable summer peak, the flush cannot be relied on, and a failure of summer rain means no chance of growth till next summer. If, on the other hand, rainfall is more evenly distributed through the year, no flush can be predicted, but good pasture growth may be expected in almost any season of the year. Cunnamulla gives an example of this (see Figure I).

An analysis of the quarterly wool production and end of quarter body weights of sheep grazing on Mitchell grass pastures at Cunnamulla from 1942 to 1945 supports this conclusion. There were 16 quarterly periods in the four years, each quarter representing a season within a year. The 12 wethers observed were spread over three different grazing treatments. It was possible to carry out an analysis of variance for differences between season. Although there were some differences between seasons for both wool weight and body weight, for neither character were they significant statistically. However, in an analysis of the same data involving 16 quarterly periods, highly significant differences between periods were demonstrated for both characters. The relevant mean quarterly and mean seasonal production figures are given in Table I.
Figure 1.
Quarterly measurements of dry matter available to sheep on a Mitchell grass pasture at Cunnamulla with monthly rainfall recordings for the years 1941-1951.
TABLE 1.
Mean Quarterly and Mean Seasonal Wool Production and Body Weights of 12 Merino Wethers Grazing on Mitchell Grass Pasture from 1942 to 1945.

<table>
<thead>
<tr>
<th>Season</th>
<th>1942</th>
<th>WOOL PRODUCTION (lb.)</th>
<th>1943</th>
<th>1944</th>
<th>1945</th>
<th>Mean</th>
<th>1942</th>
<th>1943</th>
<th>1944</th>
<th>1945</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>November–January</td>
<td>2.6*</td>
<td>3.1</td>
<td>2.5</td>
<td>2.9</td>
<td>2.8</td>
<td>.....</td>
<td>82.1</td>
<td>95.9</td>
<td>93.3</td>
<td>92.2</td>
<td>90.9</td>
</tr>
<tr>
<td>February–April</td>
<td>2.4</td>
<td>3.0</td>
<td>2.2</td>
<td>2.4</td>
<td>2.5</td>
<td>.....</td>
<td>85.2</td>
<td>103.0</td>
<td>91.9</td>
<td>99.9</td>
<td>95.0</td>
</tr>
<tr>
<td>May–July</td>
<td>2.4</td>
<td>2.4</td>
<td>1.8</td>
<td>3.1</td>
<td>2.4</td>
<td>.....</td>
<td>81.9</td>
<td>97.6</td>
<td>85.2</td>
<td>98.9</td>
<td>90.9</td>
</tr>
<tr>
<td>August–October</td>
<td>3.2</td>
<td>2.0</td>
<td>2.0</td>
<td>2.1</td>
<td>2.3</td>
<td>.....</td>
<td>102.5</td>
<td>93.2</td>
<td>96.8</td>
<td>104.9</td>
<td>99.4</td>
</tr>
</tbody>
</table>

* Quarter ending January, 1942.
The amount and seasonal distribution of feed produced by pasture in such an environment is not subject to regulation or control by the land-holder. The first essential requirement for maximum production can be met during some periods but not in others.

(c) Effect of Rainfall in a Series of Consecutive Years

Many semi-arid pastures contain not only grasses and herbs, but also edible trees and shrubs. In southern Queensland and northern New South Wales the most important and widespread edible tree is the mulga (Acacia aneura).

It is convenient to consider a mulga tree as part of a crop with a long growing period rather than as a permanent asset which must be kept alive at all costs. Once past a certain age it does not necessarily increase the amount of leaf produced, and that which it does produce becomes more expensive to make available to sheep. The initial stage of the life of a mulga crop is its germination and growth to a height at which it is not grazed by sheep. This requires a sufficient number of consecutive years of good rainfall with associated grass and herbage growth to give an alternative ration and ensure that the young tree will not be overgrazed.

A series of such years occurred in south-west Queensland from 1947 to 1956, during which time many good stands of mulga grew to a safe height and became a fodder reserve.

III. TOTAL PASTURE CONSUMPTION

(a) Variation in Feed Available between Years

(i) Fodder conservation.—Surplus feed grown in good years may be carried over as standing feed, or conserved as bush hay if suitable grassland is available. Standing feed in the form of mulga may be conserved for a long time, but in the form of pasture its life is limited due to deterioration.

(ii) Stocking rates.—A more effective method of consuming as much as possible of the fodder grown is to change the stocking rate to suit the pasture, as by purchase of sheep in good years or by sale of sheep in bad years. This approach would apply to stocking with either breeding ewes or wethers, one advantage of the former being that stocking can be reduced by suspending mating in a bad year. It is often impracticable to change the stocking rate economically by either method, as generally the same seasonal conditions apply over a wide area.

Frequently the rate of stocking on a pastoral property does not change greatly from year to year, but the amount of pasture wasted does.

(b) Variation in Feed Available between Seasons

(i) Fodder conservation.—Saving of paddocks is the only method practised of conserving fodder grown in one period of the year for use in another. The size of the rabbit and kangaroo population will have a bearing on its utility, especially during a poor year.

(ii) Stocking rates.—On a breeding property stocking rates increase regularly each year at lambing. If rain, followed by pasture growth, may be expected at almost any time of the year, it is difficult to mate so that lambing will coincide each year with a flush growth period.

(c) Modifying the Environment

The minimum carrying capacity of a property may be raised by introducing superior pasture species, such as Buffel grass, by growing a crop for ensilage, or by irrigation. The areas in which these meas-
ures can be taken are limited. Rainfall, soil type, and, for irrigation, the available water supply, are controlling factors.

Apart from any increased productivity of sheep during dry periods which may follow, any improvement of the environment will also ensure that a higher stocking rate may be applied during a later wet period.

IV. EFFICIENCY OF FOOD UTILISATION

(a) Production System

The only alternative type of production to fine wool-growing is store or fat cattle raising. This is carried on to a limited extent with wool-growing on many properties.

With sheep, the alternatives available are straight wool-growing, with wethers, and wool-growing combined with breeding. The latter course is not practicable in some areas, but where it is, a breeding flock offers more opportunity for varying the stocking rate than does a flock of dry sheep.

(b) Individual Animals

The gross efficiency (Ferguson 1958) of conversion of food to wool is one of a number of characters which could be important in a selection programme for increased clean wool weight. Gross efficiency would be important when food is limiting, and maximum wool production per unit of food consumed is required. When food supply is not limiting, maximum wool production per head would probably be a more important character.

If wool production per unit of food consumed is not of consistent importance, it would be better omitted from any selection programme to allow a greater selection pressure to be applied for clean wool weight per head. In fact, selection for high clean wool weight per head in a flock of medium Peppin Merinos under grazing conditions (described by Turner, Dolling and Sheaffe, 1959) has also resulted in selection of more efficient animals (C.S.I.R.O. Annual Report 1957-8, Dolling and Moore, 1960) so no genetic antagonism between the two characters need be anticipated with this Merino strain. Using wool weight per pound of body weight as an estimate of efficiency Turner (1959) has shown that the genetic correlation between this ratio and wool weight per head is likely to be positive in all strains, and sometimes very strongly so.

V. PASTURE CONSUMPTION PER HEAD

Several means of increasing the amount of total pasture consumed have been enumerated. An additional way is to increase to a maximum the consumption per head when pasture is not limiting.

It may well be argued that the most profitable sheep for the environment under discussion is that which will:—

(a) consume a maximum amount of food in time of plenty,

(b) survive a drought to present itself for a succeeding flush period, and

(c) grow a maximum amount of wool per unit of food consumed during drought and semi-drought periods.

Schinckel (1960 in press) has shown that differences in wool production between high, medium and low wool-producing sheep born at Cunnamulla in a random mating group of medium Peppin Merinos arose from differences in both efficiency of conversion and feed intake. Moreover, there was a positive correlation between efficiency of conversion and appetite — high wool-producing sheep tended not
only to be more efficient, but also to have greater appetites. Unless there is an important interaction in efficiency between individual sheep and plane of nutrition, and there is some evidence that this is not so (Dolling and Moore, in press), the sheep able to consume most in time of plenty may be expected to display a higher efficiency of conversion at other times.

Changing the genetic composition of a flock by selection for high clean wool production per head is probably the most satisfactory method of increasing food consumption per head under good nutritional conditions. Such selection would amount to a further form of conservation of fodder. Nutrients are conserved as body tissue and subsequently converted to wool when food intake falls below maintenance level (Ferguson, 1958).

Increased food consumption may be achieved by other means. The administration of thyroxine to Merinos causes an increase in feed intake and a consequent increase in wool growth (Ferguson, 1958). Although body weight and the net efficiency of wool growth were found to decline, these disadvantages could possibly be outweighed by the increased wool growth.

Before thyroxine could be considered for commercial use one would need to determine whether or not it would display a residual effect after a period of flush pasture growth had passed. Should it do so, the ability of an animal to survive a drought or to produce wool efficiently when pasture intake is low could be affected. The advantageous carry-over of nutrients as body tissue described by Ferguson for the non-implanted animal would probably be lost because the increased metabolic rate of the implanted animal would probably not permit body reserves to be laid down. No experimental work has been reported on the administration of thyroxine to sheep in our semi-arid sheep belt.

VI. ACKNOWLEDGEMENT

Thanks are extended to Messrs. R. Roe and G. H. Allen for their making available “Gilruth Plains” pasture data additional to that already published.

VII. REFERENCES

Taylor, G. (1951).—“Australia”, Ch. 4 (Methuen; London).
DISCUSSION

D. N. Sutherland (Qld.) asked how the stocking rate was calculated in view of the wide seasonal variations which occur.

Answer.—Stocking rate on the mulga association has remained constant at one breeding ewe with her lamb (to weaning) to eight acres until the recent drought. This is a conservative rate of stocking but cannot be increased economically to consume the additional pasture available.

Dr. P. G. Schinckel (N.S.W.).—If we are interested in efficiency of feed conversion, the most practical way to improve sheep may be to select for the amount of wool they produce. This is a function of the amount of feed consumed and the efficiency of conversion.

Answer.—In some periods food consumption is more important than efficiency while the reverse may be the case in periods of semi-drought. The relative importance of the two components of wool production varies in different environments.

Dr. R. B. Dun (N.S.W.).—Selection for clean fleece weight at Trangie resulted in an increase of about $2\frac{1}{2}$% per annum. Selection had increased both food consumption and efficiency of conversion. Both characters are of value in the unimproved areas with a low productivity with occasional unpredictable feed flushes.

Answer.—In a comparison between two families of sheep, one selected for high and the other for low clean-fleece weight, their relative productivity on pasture was in the ratio of 124:100. When fed to maintain a constant body weight this changed to 110:100 (the body weights were similar). In pens, their net efficiencies were in the ratio 108:100. Selection for clean fleece weight has resulted in more efficient sheep.