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SHEEP AND WOOL PRODUCTION IN THE DIFFERENT ECOLOGICAL REGIONS IN AUSTRALIA WITH EMPHASIS ON DEVELOPMENTS IN BREEDING

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The different sheep growing regions of Australia can be classified in numerous ways. They range from humid to semi-arid; from winter rainfall to summer rainfall; from 20° south in the tropic zone down to 42° south in the temperate zone.

To look at the country region by region would involve too much detail and probably not yield a useful picture. The following shall therefore be considered:

The sheep and wool industry

Livestock density

Generally speaking, the regions of Australia with the highest stocking densities of beef cattle, dairy cattle and sheep are in the higher rainfall areas. Dairy cattle contribute heavily to the regions in Victoria which carry 6,7 to 13,5 sheep equivalents (s.e.) per hectare (ha), although sheep are the more important in the western region of this, the most densely stocked area of Australia (Anon, 1957, 1968, 1970).

Sheep play a major role in the 3,7 to 6,7 s.e. per ha regions of South Australia, Victoria and New South Wales. All six States have extensive regions stocked from 0,6 to 3,7 s.e. per ha, mainly by sheep. Stocking rates lower than these exist towards the interior of the continent (Anon, 1957, 1968, 1970).

These livestock densities have been calculated for each local statistical area from the average livestock numbers for 1965–67 and the area of rural holdings in 1966. As the total area of rural holdings was considered (not only that land actually grazed by livestock), the densities quoted are very much lower than one is accustomed to thinking of in, say, a grazing experiment, or on a property given wholly to a sheep enterprise.

Distribution of sheep

By far the greatest part of the Australian sheep flock is between the 800 mm and the 250 mm mean annual rainfall isohyets.

Even though there is increasing diversity in the wool-growing enterprise in regions with higher annual rainfall, wool is always a major product.

A netting fence extends from Eyre Peninsula in South Australia, east to the New South Wales border, and thence northwards to surround the sheep belt in inland Queensland. The fence was erected to hold the wild dog, or dingo, out of the sheep country and in the cattle country to the north.

New South Wales has about 40% of the total sheep population, Western Australia 19%, Victoria 18%, South Australia 11%, Queensland 9% and Tasmania 3%.

Trends in wool production prices

Greasy wool production has increased from about 500 000 tons in the early 1950's to a peak of 923 405 in 1970 (Anon, 1973), this from a record total of 180 million sheep.

Since the sharp peak of 1951, wool prices have, of course, gradually fallen, with the exception of the very valuable firming of prices in the 1972/73 wool selling season.

Wool exports

Wool is shipped from 11 ports between Perth and Brisbane. At each there is a wool auction. There are, in addition, two inland wool auction centres.

There has been a gradual decline in the percentage contribution which wool has made to the total value of exports. In 1950, wool accounted for 50% of the value of exports, being well ahead of any other single commodity. Manufacturing and mining have since increased so much that, in 1971, minerals displaced wool as the largest export earner for the first time. For several commodities, the percentage of total value of exports in 1971 were wool 13%, wheat 10%, meat 10%, and minerals (other than gold) 14% (Chapman, Williams & Moule, 1973).

About 6% of the clip is processed in Australia. Some of this is exported as tops or yarns, some as scoured or carbonized wool.

Wool production and sheep reproduction over Australia

Two very useful series of maps have been compiled from census figures on wool production and lamb production (Anon, 1957, 1968, 1970; Brown & Williams, 1970).

Average clean fleece weights

Average clean fleece weights for adult sheep (excluding lambs) have been calculated, for each statistical district, from greasy fleece weight and estimated yield. Averages for the five year period 1960–65 were quoted (Brown & Williams, 1970).

A marked north-south trend was present; the lowest average clean fleece weights of less than 2,3 kg were in the semi-arid pastoral areas of northern Queensland and Western Australia, in the dry tropics.

The highest average clean fleece weights, over 3,2 kg, were in the temperate semi-arid areas of South Australia and Western Australia. Large areas cutting over 3,0 kg per head were in these two States and in semi-arid western New South Wales. In the coastal and high rainfall areas of southern Australia, most districts were above 2,7 kg.

In addition to average clean fleece weights, maximum annual clean fleece weights were plotted to determine if average fleece weights of sheep in districts with low production could, in a good year, approach those of districts with high average fleece weights. The pattern did not change; in a good year in *any* district, average clean fleece weights increased some 0,2 to 0,5 kg; the north-south trend was still present (Brown & Williams, 1970).

Predominant wool styles

Most Australian wools are combing wools with staple lengths greater than 35 mm, and are used in the worsted industry. Shorter wools are used in the woollen industry (Chapman, Williams & Moule, 1973). Of the combining wools, the best styled or spinners wools are produced in the high rainfall zone in the south-east of South Australia, Victoria, Tasmania, and the southern Tablelands and New England regions of New South Wales (Chapman, Williams & Moule, 1973).

The better topmaking wools are produced in the cereal zone of South Australia, Victoria and New South Wales, and in the best areas of the drier pastoral zone of Western Australia, South Australia, New South Wales and Queensland.

Inferior topmaking wools are grown elsewhere in the pastoral zone, and in parts of the cereal zone, of the same four States (Chapman, Williams & Moule, 1973).

Lamb marking percentages

A clear north-south trend was present in both western and eastern Australia. Large areas in and just below the tropics had from 20 to 40 lambs marked per 100 ewes mated during the period 1960–65 (Brown & Williams, 1970).

The highest percentages, over 80, were in the southern coastal and higher rainfall areas of both the west and the east. Percentages of 60 to 80 prevailed in the temperate semi-arid pastoral zone where the highest average fleece weights were recorded (Brown & Williams, 1970).

Factors affecting variation in production over Australia

Type of sheep

The higher average clean fleece weights recorded in the pastoral zone of South Australia, in parts of western New South Wales, and in parts of Western Australia reflect the high incidence of the South Australian strong wool strain of Merino.

In the southern coastal districts the average lamb marking percentages are greater among non-Merinos than they are in adjacent regions where Merinos form a higher proportion of the total population (Brown & Williams, 1970).

Distribution of wethers

No consistent picture exists on the extent to which regional variations in clean fleece weight may be attributed to the proportion of wethers in a district.

However, if ewes in breeding flocks were maintained at higher levels of nutrition than wethers, any expected difference in wool cuts between districts with high ewe and high wether populations would be muted as a result.

Reproductive status and age of ewe

The nutritional demands of pregnancy and lactation impose a penalty on wool growth rate (Williams & Suijdendorp, 1968). Wool production per head in a flock of Peppin Merinos in Queensland decreased from 3 to 4 years of age onwards (Brown, Turner, Young & Dolling, 1966), while the number of lambs weaned per ewe joined increased up to 6 years of age (Turner & Dolling, 1965).

However, it is difficult to invoke these relationships in attempting to interpret production differences between statistical districts, because of the likelihood of their interaction within the production systems.

Pasture and rainfall

The north-south trend in wool growth reflects:

- the distribution of rainfall throughout the year, and
- the ability of the vegetation to respond to rainfall.

In the north, the summer monsoonal rain is accompanied by a short peak in wool growth rate, followed by a period with little pasture growth.

Further south, but still in the semi-arid zone, rainfall in either summer or winter, coupled with the ability of the vegetation to respond to rainfall at any season, causes a reduction in the length of periods of low wool growth rate.

The greatest between year variation in fleece weight occurs where both summer and winter rainfall are likely. Coefficients of variation of greasy fleece weights between years for the five year means range from 7 to 15. The coefficients are less than 5 in the northern summer rainfall and in the southern winter rainfall areas (Brown & Williams, 1970).

Over a large area of eastern Australia, in the higher rainfall regions, there is little regional variation in fleece weight, which is consistent with there being a general management policy of maintaining sheep in "good" condition through the manipulation of stocking rates (Brown & Williams, 1970).

Climate

Although considerable work has been done on the effect of temperature *per se* on wool growth, it is not possible to interpret commercial production figures in the light of this work because of the confounding in the field of temperature with factors such as photoperiod and food intake.

Heat-induced sterility in rams has been demonstrated following relatively short exposure to high air-temperatures (Moule & Waites, 1963). Rams with highly wrinkled skin exhibit heat-induced sterility at lower heat loads than do plain bodied rams, and they recover more slowly (Fowler & Dun, 1966).

Mating in many regions does coincide with the period of high heat loads, so temporary infertility could well be a problem in the field in such cases.

Sheep enterprises in the three wool-growing zones

The Bureau of Agricultural Economics, in surveys of the sheep industry, divides the sheep grazing regions into three broad zones on the basis of climate, pasture, and type of sheep grazing enterprise (Chapman, Williams & Moule, 1973).

Table 1

Numbers of sheep and of properties in the zones, 1969 (Chapman, Williams & Moule, 1973)

	Pastoral zone	Wheat sheep zone	High rainfall zone
Number of sheep	39.500.000	77.100.000	57.400.000
Percentage of total number of sheep	22,6	44,2	32,9
Number of properties	7.200	50.000	34.400
Percentage of total number of properties	7,9	54,6	37,5

Exclude about 20.000 properties, each with fewer than 200 sheep.

Table 2

Average capital investment per sheep equivalent, 1970 (in dollars) (Chapman, Williams & Moule, 1973)

Item	Pastoral zone	Wheat sheep zone	High rainfall zone
Improvements	8,1	10,8	7,6
Plant and machinery	2,3	7,9	3,9
Livestock	5,8	7,7	8,2
Capital (excluding land)	16,2	26,4	19,7
Land	11,2	34,6	28,9
TOTAL	27,4	61,0	48,6

The *pastoral zone* occupies the semi-arid and arid regions of Western Australia and South Australia (mean annual rainfall 150 to 250 mm), New South Wales (200 to 400 mm) and Queensland 250 to 650 mm). Stocking rates range from one sheep to 2 ha to as low as one sheep to 40 ha; all pastures are of nature vegetation.

The *wheat-sheep zone* extends from south-eastern Queensland (600 to 750 mm), through New South Wales (400 to 650 mm) and into Victoria, South Australia and Western Australia (all with mean annual rainfall 250 to 500 mm). Most of the wheat and barley grown in Australia is produced in this zone.

The *high rainfall zone* is between the coast and the wheat-sheep zone in Western Australia (500 to 1 000 mm), South Australia (500 to 750 mm), Victoria (500 to 1 000 mm) and New South Wales (600 to 1 000 mm). All of the Tasmanian sheep grazing area is in this zone (500 to 1 000 mm). Pasture improvement with fertiliser and introduced legumes and grasses is widely practised in this zone.

The numbers of sheep and of properties in each of these three zones are set out in Table 1.

The average number of sheep handled per unit of labour differs considerably between zones – about 2 500 in the pastoral zone, about 1 000 in the wheat-sheep zone, and about 1 500 in the high rainfall zone (Chapman, Williams & Moule, 1973). In the pastoral zone in Western Australia, up to 12 000 sheep can be handled by a single labour unit (Fels, 1971).

The average capital investment per sheep equivalent is much lower in the pastoral zone than in the other zones (Table 2). Much of the pastoral zone of Queensland and New South Wales, and most of the zone in Western Australia, is leasehold, so land is an insignificant part of the capital of wool growers in these regions.

The land use and flock composition on properties in the Bureau of Agricultural Economics survey are given in Table 3. The importance of improved pastures in the high rainfall zone is evident. The slightly higher percentage of breeding ewes in the pastoral zone than in the other zones reflects the difficulty of rearing adequate flock replacements in parts of this zone.

The average production figures for the properties sampled are set out for each zone in Table 4. The

Table 3

Land use and flock composition, 1970 (Chapman, Williams & Moule, 1973)

	Pastoral zone	Wheat sheep zone	High rainfall zone
Land use			
Native pasture	23.154	321	142
Improved pasture	145	403	340
Total crops	131	254	31
Total area per property (hectares)	23.430	978	513
Flock composition (%)			
Ewes	54	49	42
Wethers	18	19	24
Hoggets	9	8	8
Lambs	18	23	25
Rams	1	1	1

Table 4

Average production per property, 1970 (Chapman, Williams & Moule, 1973)

Item	Pastoral zone	Wheat sheep zone	High rainfall zone
Sheep	5.619	1.649	1.806
Cattle	146	54	93
Wool produced (kg)	27.012	7.755	8.754
Wool per head (kg)	4,6	4,3	4,2
Wool price (cents per kg)	74,1	81,1	90,6
Lamb marking percentage	62,4	75,9	83,9
Sheep equivalents per hectare used	0,30	2,22	5,56
Wool per hectare used (kg)	1,23	8,23	19,07

Table 5

Returns from sheep, cropping and cattle in each zone, 1970 (Chapman, Williams & Moule, 1973)

	Pastoral zone	Wheat sheep zone	High rainfall zone
Sheep enterprise (as percentage of total returns)	76,3	48,4	65,6
Cropping enterprise	6,6	35,7	9,8
Cattle enterprise	15,4	11,7	20,7

properties had been chosen as having sheep enterprises as their main sources of income, but cattle are an important adjunct in each zone. The wool cut per head is slightly higher on the pastoral zone properties, but the price per kg increased from the pastoral to the wheat-sheep to the high rainfall zones. The lamb marking percentages also increased in the same fashion.

The great differences in stocking rates between zones, and in wool produced per hectare used, are clearly seen. As mentioned earlier (under Livestock density), the method of calculation of these figures is such as to result in their being lower than one finds recorded for individual grazed areas of land in the zones. This is less so for the pastoral zone (in which most land "used" is, in fact, grazed) than it is for the high rainfall zone. An example of the production from a single grazed area in the high rainfall zone is that of 117 kg greasy wool per ha from 20 Merino wethers in the south-east of South Australia; this was the average annual production over a five year period (Hawthorne, 1975).

The relative financial contributions of sheep, cropping, and cattle enterprises to the properties sampled are shown in Table 5. Cattle are relatively more important in the high rainfall than in the other zones.

The strains of the australian merino

Given the great range in levels of production in different regions, and the great differences between regions in their climates and vegetation, one is led to ask the question "Have the different strains of the Merino been selected to develop special adaptations to the regions in which they were developed? "

Fine-woolled Merinos were developed in Tasmania, in western Victoria, and in certain tableland areas of eastern New South Wales. These are areas of temperate climate, of high average rainfall, with a high degree of reliability from year to year. The strong-woolled strain was developed in the Mediterranean type climate of the mid-north of South Australia, where the winter rainfall is moderate in amount but of high reliability. The two medium-woolled strains originated on plain country in northern and south-western New South Wales with moderate rainfall of a lower reliability, areas characterized by high summer temperatures (Dolling, 1970).

Broadly speaking, the fine-woolled Merino strain may be said to have developed from the finer Merinos introduced into the colonies in the first half of the Nineteenth Century. The medium-woolled strain of northern New South Wales sprang from the same sheep. The strong-woolled strain originated largely from sheep driven from New South Wales to South Australia. The possibility of there having been an infusion of some genes from British longwool sheep has often been a subject for debate. The fourth strain is the Peppin Merino, the medium-woolled strain originating in south-western New South Wales in the Riverina district; this strain is now the most populous in the country (Dolling, 1970).

Differences between the strains

Any set of production figures comparing the strains in one particular environment suffers from the shortcoming that it shows what each of the strains can do in one environment only. If, in fact, the strains have been designed by breeders each to do best in its home environment, then the relatively performances of the strains would be expected to differ between some environments, at least. Fortunately production figures are available for five different Merino strains, each in three different localities during the same years (Dunlop – personal communication). The original ewes obtained to represent each strain were dispersed at random to the three localities. No artificial selection was practised on sheep born in any flock, so divergence of the levels of genetic merit in the three sub-flocks of a strain was kept to a minimum. As a result, differences between strains in one environment, or differ-

Table 6

Production of ewes of five merino strains in three environments (Dunlop – personal communication)

Character	Strain	Pastoral zone		High rainfall zone
		Cunnamulla Queensland	Deniliquin New South Wales	Armidale New South Wales
Body weight (kg)	Fine	32,2	37,2	34,0
	Medium	34,5	40,4	32,2
	Peppin B	35,8	42,6	34,9
	Peppin A	38,6	44,0	37,2
	Strong	39,9	45,4	40,8
Clean wool weight per head (kg)	Fine	2,4	3,0	2,1
	Medium	3,0	3,4	2,3
	Peppin B	3,3	3,8	2,6
	Peppin A	3,2	4,0	2,7
	Strong	3,6	4,6	3,3
Lambs born per 100 ewes mated	Fine	82	83	75
	Medium	96	93	75
	Peppin B	87	99	81
	Peppin A	73	94	92
	Strong	79	93	80

All ewes were born and reared in the environments quoted.

ences between environments within any one strain, were not confounded with differences in genetic merit within a strain.

The strains represented in these production figures are those already mentioned; the fine non-Peppin (FINE), the medium non-Peppin (MEDIUM), and the strong non-Peppin (STRONG), while the largest strain, the medium Peppin, is represented by one type originating from the Riverina (PEPPIN A) and another from northern New South Wales (PEPPIN B). The localities in which the strains were run for a number of years were Cunnamulla in Queensland and Armidale and Deniliquin in New South Wales. The Cunnamulla rainfall averages approximately 325 mm, rain falling in both summer and winter. Armidale's average rainfall of approximately 750 mm has a slight summer trend; low temperatures restrict pasture growth in the winter. Deniliquin receives most of its 375 mm average rainfall in the winter; summers are hot and dry, shortage of rain limiting pasture growth at this time. Except during mating and lambing, when ewes were hand-fed in yards, ewes at Cunnamulla and Deniliquin were grazing natural pasture. At Armidale, native pastures provided the bulk of the grazing, but at critical periods such as late winter and early spring limited access was given to improved pastures, and in the drier years hay and grain were also fed.

Production figures for ewes bron and reared in each of these environments are set out in Table 6.

Adaptation to an environment

Adaptation to an environment can be in one of two forms.

An animal may adapt physiologically to the changes which take place in an environment or to the changes which it experiences on moving from one environment to another.

A species or a breed may adapt genetically to a given environment in which it finds itself for a considerable period. Man may help, or may think he is helping, this adaptive process in domestic livestock by his applying artificial selection.

A measure of genetic adaptation to an environment is given by the sign and magnitude of genotype X environment interactions observed after different genotypes have each been subjected to a number of environments.

If there are no consistent and significant interactions, then none of the genotypes can be considered to have a special adaptation to any of the environments in which it has been tested.

The large scale testing of five Merino strains in three Australian environments was designed to detect genotype X environment interactions (Dunlop – personal communication; Dunlop, 1962).

Strain adaptations to locational environments

The body weight of the Fine ewes at Armidale was higher than that of the Medium ewes, although the reverse was the case at Cunnamulla and Deniliquin in the pastoral zone (Table 6). The Fine ewes were heavier at Armidale, relative to other strains, than would have been expected from their performances elsewhere. This strain X environment interaction involved a change in ranking of the strains from one location to another.

There is no other similar interaction evident in Table 6. Many other characters were studied, with the same general conclusion – that interactions were not of great importance in most characters. In fact, it was not uncommon for the sign of an interaction to change from one year to the next for individual characters. In these circumstances, even if interactions were significant they would be of no real importance to the sheep breeder.

One consistent and significant interaction, however, was that for fleece rot, a fleece fault which may follow a period of continuous wetting of the skin of sheep (Hayman, 1953). This was not recorded at Deniliquin, showed a low incidence in three strains at Cunnamulla, but was much more prevalent at Armidale (Table 7).

The Fine ewes were still virtually free of fleece rot, but the Strong ewes had a very high incidence (Dunlop & Hayman, 1958). They were not well adapted to this high rainfall environment in terms of fleece rot, whereas the Fine strain was.

An overall conclusion was that the Fine strain did, in a number of characters, perform better at Armidale than would have been expected from its performances elsewhere relative to other strains.

No other strain did the same thing to the same extent in any of the three environments. No other strain had any special adaptation for any one of the environments tested.

In making this conclusion, one must bear in mind two reservations. One is that there may be important interactions in some characters not observed here; but most characters of cash value to the commercial breeder were. The other is that important interactions may have been found if additional localities had been tested. This may be so. But one reason for the absence of many worthwhile interactions between strain and location was the presence of many interactions between year and location which were brought about by variability in pasture conditions from one year to the next in any given location. So unless any additional environments tested had a much lower year to year variability than the native pastures at Armidale, Cunnamulla and Deniliquin, potential strain X location interactions might still remain undemonstrated.

Strain adaptation to a season of the year

There were no consistent or large strain differences in the number of lambs born per 100 ewes mated (Table 6) in what were April-May matings. The possibility remained, however, that one strain may have become adapted to mating at one season of the year, another strain to mating at another season.

Table 8

Reproductive performance of Peppin and South Australian (strong wool) Merino ewes, 1963 and 1964
(Dun, Alexander & Smith, 1966)

	Peppin	South Australian
Ewes joined		
Autumn*	145	134
Spring*	146	134
Ewes lambing (per 100 ewes joined)		
Autum	86	81
Spring	61	73
Twin births (per 100 ewes lambing)		
Autumn	33	24
Spring	29	43
Lambs born (per 100 ewes joined)		
Autumn	115	101
Spring	79	105

*Autumn joining on March 7; Spring joining on October 18

Table 7

Incidence of fleece rot in five Merino strains in three environments
(Dunlop & Hayman, 1958)

Strain	Pastoral zone				High rainfall zone	
	Cunnamulla, Queensland		Deniliquin, New South Wales		Armidale, New South Wales	
	Fleece rot		Fleece rot		Fleece rot	
	Present	Absent	Present	Absent	Present	Absent
Fine	0	640	0	366	3	858
Medium	0	394	0	206	13	341
Peppin B	7	387	0	230	24	458
Peppin A	4	369	0	220	37	499
Strong	7	721	0	369	119	709

The results of Table 8 were obtained in a testing of this possibility in which groups of both South Australian and Peppin ewes were mated in autumn (March – April), other groups being mated in spring (October – November). Strain X season of mating interactions were present for each of the three measures of reproductive performance (Dun, Alexander & Smith, 1966).

Of all ewes joined in the autumn, 5% more Peppin ewes lambed than did South Australian ewes; among the spring-joined ewes, 12% more South Australian ewes lambed. Of all ewes lambing to the autumn joining, 9% more Peppin ewes gave birth to twins; among those lambing to the spring joining, 14% more South Australian ewes dropped twins. The resultant lambing percentages to autumn and spring joinings were 101% and 105% for South Australian ewes and 115% and 79 % for Peppin ewes.

There was little difference between the strains in average performance. But an interaction of this nature should be recalled by an Australian sheep-breeder if either autumn or spring joining is precluded in any particular region.

Comment

It is probably misleading to think that there is such a thing as THE breed or strain of sheep for any given district. In many districts different breeders or strains can be reared one next to the other; the most profitable at any one time may well be determined by the relative market prices of the products of each. It may also be misleading to think that there is such a thing as THE district for a breed. In a good district, many breeds or strains may thrive; in a very harsh environment the number of breeds or strains may be reduced.

The breeder's aim is not necessarily to provide the conditions for the best biological development of his sheep; it is to ensure the best economic returns from his animals, and to do this he takes into account not only the amount and quality of the different products potentially available from different types of sheep, but also their relative cash values. The absence of a breed from a region may mean that it does not thrive biologically, that current economic conditions do not favour its products or that it has not been tried.

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