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GENETIC AND ENVIRONMENTAL EFFECTS ON HOGGET WOOL PRODUCTION OF VARIOUS CROSSES BETWEEN THE DORSET HORN, MERINO AND CORRIEDALE BREEDS OF SHEEP

*W.S. PITCHFORD** and *T.S.* CH'ANG*

SUMMARY

This study investigates the importance of various genetic and environmental effects on clean fleece weight (CFW) and fibre diameter (FD) of hogget sheep resulting from all possible crosses between the Dorset Horn, Merino and Corriedale breeds. All environmental effects were influential in determining CFW and FD, with year of birth being the most important. The most important genetic effects in determining CFW and FD were additive (direct) effects. Maternal effects were less important. Overall, crossbreds exceeded purebreds by 13% for CFW and 2% in FD.

INTRODUCTION

Crossbreeding is a means of bringing together desirable characteristics of two or more breeds. In addition to the qualities of the breeds themselves, there may be specific advantage in a particular cross. Often crossbred performance is greater than the mean of the two parent breeds; this increased performance is known as hybrid vigour or heterosis.

Crossbreeding plays an important role in the Australian sheep industry, especially for lamb production. Returns from wool and meat are important sources of income for lamb producers. This study investigates the relative importance of various genetic and environmental effects on hogget clean fleece weight (CFW) and fibre diameter (FD), the two major traits determining fleece value,

METHOD

The sheep in this study were raised at Arding, near Armidale, N.S.W. Lambs were born each year from 1973 to 1982. Data for rams born in 1977 and 1978 are not available. Lambs were generally born during October, marked in December, weaned in January and hogget measurements were taken at approximately 15 months of age in the following January, although this did vary from year to year. Ram lambs were not castrated. Numbers of sheep in each cross are shown in Table 1.

A model including factors of breed of sire (BOS), breed of dam (BOD), the interaction between breed of sire and breed of dam (BOS*BOD), year of birth (YR), and age of dam (AOD) (2-9 years) was fitted to the two traits using least squares techniques (Harvey 1964). Initial analysis showed significant SEX*BOS and SEX*BOD interactions so the present analyses were done separately for rams and ewes. Linear contrasts between least squares means were used to calculate direct genetic (gI), total maternal (mT), and individual heterotic (hI) effects as shown in Alenda et *al.* (1980).

RESULTS AND DISCUSSION

Environmental effects

Age of dam effects on ewes CFW were significant ($P<0.05$) and all other factors in the model had a significant ($P<0.01$) effect on the two traits and both sexes

* *CSIRO, Division of Animal Production P.O. Box* 239, *Blacktown, N.S.W. 2148.*

in this study. Variation in FD was due more to genetic effects (BOS, BOD, BOS*BOD) than environmental effects (YR & AOD). Environmental effects accounted for more variation in CFW than genetic effects, The model accounted for most of the variation in each of the traits (Rams: 74% FD; 72% CFW; Ewes: 76% FD; 67% CFW). The coefficient of variation was 19% for CFW and 9% for FD. The residual correlation between the two traits was around 38%.

Hogget rams from mature dams had 10% higher CFW ($P<0.01$) and 5% higher FD ($P<0.01$) and hogget ewes had 4% higher FD than those from maiden (2 year old) dams. Differences in CFW between ewes from maiden and mature dams were not significant. Turner *et al.* (1968) reported that Merino lambs from mature ewes had 7% higher CFW and 1% higher FD than lambs from maiden ewes. This effect is probably similar to that of being a twin lamb compared to a single.

Year of birth was the most important determinant of CFW and had a similar effect to BOS and BOD on FD. Effects were similar for rams and ewes. The highest CFW was of those born in 1973 and was 112% higher than 1979, the lowest. The FD of those born in 1973 was 21% higher than 1979. Those born in 1973 were shorn at weaning and at 15 months whereas those born in 1979 were shorn in the September at 11 months of age, which probably explains the huge yearly variation. By fitting year as part of the model yearly differences have been corrected for sufficiently to allow accurate estimation of genetic effects,

It was found that ewes had 2% higher CFW and 3% higher FD than rams. This is opposite to what was expected but previous studies in the Armidale area (Turner and Jackson 1978) found, in all the years studied, hogget Merino ewes had higher CFW and, in most years, a higher FD than their male counterparts. Analysis of hogget body weight data from this experiment (Pitchford unpublished) has shown that rams weighed more than ewes at the time of sampling. The rams in this experiment were left entire and so rams and ewe lambs were run separately after weaning, however management differences were minimised by regular rotation of paddocks.

Genetic effects

As stated above, BOS, BOD, and BOS*BOD effects were important ($P<0.01$) for both traits. The main effects (BOS, BOD) were much more important than the interaction (BOS*BOD), but the significant interaction indicates that non-additive effects are present, Individual, or direct, genetic effects measure the additive portion of the genotype; that which is transmitted from parent to offspring. Maternal effects as calculated in this study measure the differences between reciprocal crosses. Individual heterosis measures the deviation from the mean of the parent breeds and is, therefore, a measure of the non-additive genetic effects.

As shown in Table 1, the cross with the highest CFW was the COxMO and the lowest, the DH. Dorset Horn had the highest FD and the Merino the lowest.

Sex differences were not consistent over all breed combinations, as shown by significant SEX*BOS and SEX*BOD interactions in previous analyses. This is reflected in the purebred means (Table 1): Dorset Horn rams had 17% lower CFW than DH ewes; Merino rams and ewes had the same CFW; and Corriedale rams had 6% higher CFW than ewes,

Table 1 Least squares (± s.e.) means for hogget wool production of various breed crosses

Trait:	Male No.	Male CFW	Male FD	Female No.	Female CFW	Female FD
DH	152	0.97±0.03	27.6±0.2	176	1.17±0.03	28.8±0.2
MOxDH[a]	54	1.51±0.05	22.4±0.3	75	1.62±0.04	23.8±0.2
DHxMO	69	1.63±0.04	22.7±0.3	119	1.72±0.03	23.9±0.2
COxDH	43	1.67±0.05	27.4±0.3	90	1.74±0.04	27.7±0.2
DHxCO	133	1.73±0.03	26.8±0.2	196	1.74±0.02	27.7±0.1
MO	121	1.82±0.03	18.4±0.2	151	1.82±0.03	18.4±0.2
CO	193	1.92±0.03	24.5±0.2	262	1.81±0.02	24.8±0.1
MOxCO	121	1.96±0.03	21.5±0.2	178	1.99±0.03	22.0±0.2
COxMO	73	2.10±0.04	22.1±0.3	131	2.03±0.03	22.2±0.2
Grand mean	959	1.70±0.02	23.7±0.1	1378	1.74±0.01	24.4±0.1

Abbreviations: CFW, clean fleece weight (kg); FD, mean. fibre diameter (um); DH, Dorset Horn; MO, Merino, CC, Corriedale
[a] The sire breed is given first in the crosses

Table 2 Genetic effects of various breeds on hogget wool production (mean ± s.e.)

Trait:	Male CFW	Male FD	Female CFW	Female FD
Direct genetic effects (g^I)				
DH	-0.54±0.04**	4.0±0.2**	-0.40±0.03**	4.8±0.2**
MO	0.16±0.04**	-5.4±0.2**	0.17±0.03**	-5.6±0.2**
CO	0.38±0.03**	1.4±0.2**	0.22±0.03**	0.8±0.2**
Total maternal effects (m^T)				
DH	-0.02±0.01*	0.0±0.1	-0.01±0.01	0.0±0.0
MO	0.03±0.01**	0.1±0.1	0.01±0.01*	0.0±0.0
CO	-0.01±0.01	-0.1±0.1*	0.00±0.01	0.0±0.0
Individual heterotic effects (h^I)				
DHMO[a]	0.17±0.04**	-0.5±0.2	0.17±0.03**	0.2±0.2
DHCO	0.25±0.04**	1.1±0.2**	0.25±0.03**	1.0±0.2**
MOCO	0.16±0.03**	0.4±0.2	0.20±0.03**	0.5±0.2**

* contrast is significantly different from *zero* (P<0.05)
** contrast is significantly different from zero (P<0.01)
Abbreviations: CFW, clean fleece weight (kg); FD, mean fibre diameter (um); DH, Dorset Horn; MO, Merino; CO, Corriedale
[a] estimates pooled for the two reciprocal crosses involved

Direct genetic effects (Table 2) were significant for both traits and all breeds. Direct effects were similar for the two sexes although there were some important differences. The Corriedale transmitted the greatest CFW, followed by the Merino and the Dorset Horn. The Dorset Horn transmitted the greatest FD, the Merino the least and the Corriedale was slightly greater than the mean of the population. These simply reflect the different selection pressures that have been placed on these breeds over the years, Direct effects on CFW varied more in the ram than the ewe. The effects may be summarised as follows: g^I DH ram < ewe; g^I MO ram = ewe; g^I CO ram > ewe.

Maternal effects were generally not important although there was a positive effect of the Merino dam on CFW. This may be a similar effect to that of the twin versus single effect or the mature ewe effect. However, other studies on this experiment (Pitchford unpublished) have shown a significant negative effect of the MO dam on birth and weaning weights, so the increased CFW effect is not just caused by increased nutrient availability because that favours growth as well. There must be something about the Merino dam that favours increases in CFW. Perhaps the effect is a pre-natal effect conducive to follicle development. The slight negative effect of the Dorset Horn dam on rams' CFW and the Corriedale dam on rams' FD should also be noted.

Heterosis estimates were similar for the two sexes, they were positive (P<O.O1) for CFW for all *crosses.* There was also a positive heterotic effect on FD for DH/CO crosses for both sexes and MO/CO cross ewes. The greatest heterosis for both traits was with DH/CO crosses. Merino crosses tended to show less heterosis, On average, crossbreds exceeded purebreds by 13% for CFW and only 2% for FD. McGuirk (1967) found that in the Border Leicester by Merino cross heterosis was 10% for CFW. Sidwell *et al.* (1971) found that for ewes, heterosis was 6% for CFW and 2% for FD. Gallivan et *al.* (1987) found heterosis was -9% for wool grade and 13% for greasy fleece weight, In conclusion, although the effect of heterosis on wool traits is not as clear cut as it is for traits such as fertility, prolificacy, fitness and growth rates there is still ample evidence that crossbreeding can increase fleece weights without substantially increasing fibre diameter.

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