
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Follicle and fleece characteristics of Merinos, Romneys and Merino-Romney crossbreds

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ABSTRACT

Skin and fleece samples were taken from 637 ewes of Romney (R), Superfine Merino (SFM), Local Merino (LM), Superfine Merino x Romney (SFMxR), Local Merino x Romney (LMxR) and Backcross (BX) (3/4 SFM) genotypes. Secondary to primary follicle ratio (S/P), total follicle density (n(P+S)), primary follicle density (nP), mean fibre diameter (MFD), quality number (QN), staple length (SL); total crimp number (TCN); live weight (LWT) and greasy fleece weight (GFW) were evaluated.

Differences between the various genotypes, ages, years of sampling and birth/rearing ranks for these follicle and fleece characteristics were analysed. There were between genotype differences in significance of fixed effects. Genotypes having Merino ancestry with much larger follicle populations had more significant fixed effects, but year of sampling and birth/rearing rank were seldom significant. Repeatability estimates for follicle and fleece characteristics ranged from 0.44 to 0.89.

Total follicle density and primary follicle density were positively correlated but the degree of association was higher between S/P and n(P+S). Both within and across genotypes, the correlations between S/P and MFD were negative. The low correlations between nP and GFW reflect the genotypes studied, nP having less effect on GFW and MFD in breeds with Merino ancestry.

Heterosis was estimated in several ways, the means of groups representing the parent breeds being compared with the mean of each generation of the crossbred genotypes. The follicle traits, as well as MFD and QN showed negative heterosis. Live weight and GFW showed positive heterosis in the F_1 SFMxR and LMxR groups of 6.84 kg, 5.99 kg and 0.18 kg and 0.47 kg respectively. The crossbreds weighed more and produced heavier fleeces than the purebreds but with no concomitant increase in MFD over the parental breed mean.

Keywords Merino x Romney sheep; wool; follicles; crossbreeding; heterosis; phenotypic correlations.

INTRODUCTION

Fibre fineness is an important determinant of the economic value of wool. The use of fine fibre diameter wools allows the manufacture of light fabrics or alternatively, if used in thicker yarns and fabrics, the finer fibres confer properties of greater softness, flexibility and warmth. The combination of high fleece weight and fine fibre diameter is only attained in sheep of high follicle density such as Merinos.

Follicle population studies (Carter and Clarke, 1957a, 1957b) indicate that the Merino is on a different plane of follicle density from breeds which do not have Merino-based ancestry. Carter and Clarke (1957a) showed that the greater follicle density in Merinos was due to increased development and greater numbers of secondary follicles, giving a higher secondary to primary follicle ratio (S/P).

The present results arose from an investigation of the genetic control of follicle and fleece characteristics of Merino, Romney and Merino-Romney crossbred sheep.

MATERIALS AND METHODS

Sheep

Over a 2 year period (1978 and 1979), 637 ewes ranging in age from 1 to 6 years, from the Ministry of Agriculture and Fisheries flocks at Tokanui were skin and wool sampled. Although age at shearing was closer to 1½ to 6½ years it has been shortened to 1 to 6 years to simplify the text.
The flocks used in this study were:

Romney (R)
Superfine Merino (SFM) — established using imported Australian superfine Merinos.
Local Merino (LM) — descended from South Island Merinos.
Superfine Merino x Romney (SFMxR)
Local Merino x Romney (LMxR)
Backcross (BX: 3/4 SFM)

Of the sheep sampled in 1978, 143 were also sampled in 1979 to provide data for repeatability estimates. No flock of Romneys of similar ancestry to those used in generating the crossbreds was available. Instead the Romneys came from the control flock of another genetic study.

Sampling Procedures

In November 1978 and December 1979, skin samples were collected from the above flocks. Midside wool samples were taken in both 1978 and 1979 at shearing in October. Hoggets were not sampled in 1978. Preliminary analysis of the 1978 data indicated the need for increased animal number, hence hoggets were included in the 1979 sampling.

Follicle Population Determinations

Duplicate skin samples were taken from the right midside of recently shorn ewes using a method derived from that of Carter and Clarke (1957a). For each sheep, counts were made of the follicles in 10 x $1mm^2$ areas, the genotype of the sheep being unknown to the observer. From these counts the following parameters were calculated: Secondary to primary follicle ratio (S/P), total follicle density (n(P+S)) and primary follicle density (nP).

Assessments on Wool Samples

Midside fleece samples were collected at shearing in 1978 and 1979. Subjective assessments and greasy measurements were carried out, then the samples were scoured and mean fibre diameter measured by the Airflow method.

Data Analysis

The effects of age, birth/rearing rank (BRR) and year of sampling on fleece and follicle characteristics were obtained using the REG computer package (Gilmour, 1983). Repeatabilities were estimated using product-moment correlations, with data not corrected for fixed effects and ignoring genotypes. Heterosis was estimated in several ways with the means of the groups representing the parent breeds compared with the mean of each generation of the crossbred genotypes. Because the orginal parents were dead at the time this study was started, sheep of similar genotype represented the straightbred parental types.

More sheep were sampled in 1979 than 1978. Having data collected in 1978 and 1979 enabled the study of the effect of year of sampling on fleece and follicle traits. For other analyses when only 1 record per sheep was to be analysed, the 1979 record was used in preference to the 1978 record.

RESULTS AND DISCUSSION

Effects of Age, Year of Sampling and Birth/ Rearing Rank

Table 1 contains the least squares estimates of the means for follicle and fleece data in combination with the significance of fixed effects within each genotype. No interactions were included in the models, as preliminary analysis had shown them to be not significant. Age and year born were confounded. The *age* effect may be due in part to year to year variation in nutrition affecting pre-natal follicle initiation, post-natal follicle maturation and ultimate fleece weight. The estimate of the effect of the year sampled in some groups may be unreliable due to the low numbers of animals sampled in 1978 compared with 1979. The results of the present study may also have been slightly influenced by improved operator skill in histological techniques and follicle identification between 1978 and 1979.

Across all genotypes, *age* was the most consistently significant fixed effect for all traits. For characterisitics such as nP and n(P+S) this would be expected as both live weight and skin area vary with *age*. A number of authors, usually using Merinos, (e.g., Jackson *et al.*, 1975), observed that some follicles cease production with increasing age. A similar trend was noted in the present study in the crossbreds where S/P appeared to increase from *age* 1 to *age* 2 and then steadily declined. Fibre diameter (MFD), quality number (QN), staple length (SL) and greasy fleece weight (GFW) all increased with age and then declined. The changes in MFD and SL reflect changes in the follicle population, with older animals having fewer active follicles which produce coarser longer fibres.

The estimates of the effects of BRR are not particularly accurate because of small numbers of animals in some classes. The lack of significance for BRR for follicle and fleece traits may be due to the low numbers in the straightbred groups. Numbers of crossbreds were more adequate and the lack of significance here may reflect insensitivity of these animals to twin versus single rearing differences.

Both nP and n(P+S) were affected by the year of sampling concurring with the results of Jackson *et al.* (1975). Follicle density would be reduced for sheep in good condition due to skin expansion.

The between-genotype differences in significance of the fixed effects partly reflect the variation in their follicle populations. Differences due to these effects were seen more clearly in animals with Merino backgrounds and denser follicle populations.

Year to Year Repeatability

Repeatability estimates for follicle and fleece characterisitics calculated with data ignoring

TABLE 1 Least squares means (and standard errors) of traits for various genotypes together with the significance of age, birth/rearing rank and year sampled. All other effects not significant. Abbreviations for traits given in text.

Trait	R	SFM	LM	SFMxR	LMxR	BX
S/P	6.7±0.6	18.1±1.2	18.7±1.2	10.9±0.4	10.3±0.5	15.8±0.8
Age	NS	NS	NS	**	*	NS
B/Rearing rank	NS	NS	NS	NS	NS	NS
Year sampled	**	**	NS	NS	NS	NS
n(P+S)	35.7±3.2	69.7±4.6	82.1±5.8	49.6±1.7	45.9±1.9	73.6±3.7
Age	*	NS	**	**	**	**
B/Rearing rank	NS	NS	NS	NS	NS	NS
Year sampled	**	NS	NS	NS	NS	NS
nP	4.72±0.42	3.70±0.20	4.23±0.18	4.12±0.11	4.23±0.12	4.40±0.16
Age	NS	NS	**	**	**	**
B/Rearing rank	NS	NS	NS	NS	NS	**
Year sampled	NS	NS	*	NS	**	NS
LWT	54.7±2.9	44.5±2.4	47.7±1.7	48.4±1.0	61.2±1.7	44.6±1.3
Age	**	**	**	**	**	**
B/Rearing rank	NS	NS	NS	**	*	*
Year sampled	**	**	**	**	**	**
GFW	3.60±0.32	3.40±0.29	3.75±0.27	3.64±0.08	4.09±0.10	3.12±0.12
Age	**	NS	NS	**	**	**
B/Rearing rank	NS	NS	NS	NS	NS	*
Year sampled	*	NS	NS	**	**	**
MFD	37.3±2.3	20.7±0.5	22.6±0.4	26.2±0.5	28.2±0.6	21.2±0.5
Age	NS	*	**	**	*	*
B/Rearing rank	NS	NS	NS	NS	NS	NS
Year sampled	NS	NS	NS	NS	NS	NS
QN	47.5±2.3	68.7±0.9	62.2±0.1	57.2±0.6	53.7±0.6	63.5±0.9
Age	NS	**	**	NS	NS	**
B/Rearing rank	NS	NS	NS	NS	NS	NS
Year sampled	NS	**	**	**	NS	**
SL	13.90±0.85	8.12±0.25	9.11±0.32	9.99±0.26	11.23±0.31	8.68±0.33
Age	NS	NS	*	**	**	**
B/Rearing rank	NS	NS	NS	NS	NS	NS
Year sampled	NS	NS	NS	**	NS	*
TCN	15.5±1.9	49.4±2.2	38.3±2.5	32.2±1.5	28.0±1.2	41.4±2.3
Age	NS	NS	NS	**	**	**
B/Rearing rank	NS	NS	NS	NS	NS	NS
Year sampled	NS	NS	NS	NS	NS	NS
Number of ewes	52	39	45	194	170	137

genotype and not corrected for fixed effects are given in Table 2. The moderate to high repeatability of most factors indicates the lack of variation due to temporary environmental factors. The repeatability estimates are likely to be high in relation to other estimates as the genotypic differences would be greater than with most studies. Nevertheless, the repeatability estimates for S/P and n(P+S) of 0.76 and 0.74 respectively are in line with those of Young *et al.* (1960) and Jackson *et al.* (1975).

TABLE 2 Repeatibility estimates for fleece and follicle characteristics. Data were combined but not corrected for genotype or fixed effects. Abbreviations for traits given in text.

Trait	No. of samples	r
S/P	143	0.76**
n(P+S)	143	0.74**
nP	143	0.44**
LWT	110	0.66**
GFW	133	0.59**
MFD	103	0.89**
QN	106	0.72**
SL	106	0.65**
TCN	106	0.70**

Phenotypic Correlations between Traits

Correlations calculated within halfbred genotypes using data corrected for the fixed effects of age, birth/rearing rank and year sampled are shown in Tables 3 and 4. The correlations between n(P+S) and S/P (0.63 and 0.67) indicated the importance of the number of secondary follicles in determining total density. These correlations were higher than those of Nay and Hayman (1969) and Jackson *et al.* (1975) for straightbred Merinos but similar to those of Arbiza *et al.* (1966) for Merino crosses. The correlations between primary follicle density and total density were somewhat lower (0.51 and 0.43). The lower correlation probably arises from less variation in nP or greater assessment errors. In the present study there were low negative correlations between S/P and nP. The correlations between LWT and S/P were low but in line with results reported by Nay and Hayman (1969) and Gregory (1982). The correlations between n(P+S) and MFD noted in the present study (-0.48 and -0.41) agree with those reported by other workers: -0.34 (Nay and Hayman, 1969); -0.39 (Jackson *et al.*, 1975); -0.65 (Steinhagen *et al.*, 1986).. The negative correlations between GFW and total crimp number (TCN) suggest that more highly crimped fleeces have lower weights. Live weight (LWT) and GFW, MFD and SL are all positively correlated. Live weight seems to have a smaller effect on nP than on n(P+S) but an alternative explanation is that n(P+S) can be estimated more reliably and thus there is a smaller proportion of uncontrolled variation.

TABLE 3 Phenotypic correlations for fleece and follicle traits using data from SFMxR animals corrected for age, year sampled and birth/rearing rank. All other effects not significant. Abbreviations for traits given in text.

	n(P+S)	nP	LWT	GFW	MFD	QN	SL	TCN
S/P	0.67**	—0.27**	—0.05	—0.01	—0.43**	0.29**	—0.12	0.15
n(P+S)		0.51**	—0.22**	—0.11	—0.48**	0.22*	—0.04	0.19*
nP			—0.28*	—0.12	—0.14	—0.04	0.13	0.09
LWT				0.33**	0.08	0.07	—0.17	0.01
GFW					0.34**	—0.28**	0.20*	—0.19*
MFD						—0.47**	0.07	—0.46**
QN							—0.22**	0.59**
SL								0.02

TABLE 4 Phenotypic correlations for follicle and fleece traits using data from LMxR animals corrected for age, birth/rearing rank and year sampled. All other effects not significant. Abbreviations for traits given in text.

	n(P+S)	nP	LWT	GFW	MFD	QN	SL	TCN
S/P	0.63**	—0.35**	—0.07	0.08	—0.33**	0.03	—0.20*	0.05
n(P+S)		0.43**	—0.17*	0.00	—0.41**	0.12	—0.04**	0.18*
nP			—0.11	—0.09	—0.14	0.03	0.23**	0.15
LWT				0.31**	0.24**	0.02	0.20*	—0.01
GFW					0.34**	—0.27**	0.31**	—0.12
MFD						—0.44**	0.11	—0.50**
QN							—0.26**	0.50**
SL								0.02

Heterosis

It is generally considered that hybrid vigour is due to simple dominance at 1 or more loci. In this model it is expected that the full heterosis will be exhibited by the F_1 crossbreds and that, in the absence of maternal effects, the F_2, F_3 and F_4 generations will have half the heterosis of the F_1 crosses.The estimates of heterosis by different methods are shown in Table 5. It is expected that the first column of figures, the difference between the means of F_1 sheep and the mid-parent-type means, will indicate the full heterosis while the next 3 columns, the differences between the mid-parent averages and the F_2, F_3 and F_4, will only have half the heterotic effect exhibited in column 1. The reliability of the heterosis estimates was compromised by the small size of the parental groups and the fact that the animals sampled were not true parents of the F_1 crossbreds.

Follicle Characterisitics

Most estimates of heterosis for follicle traits within genotypes were negative. Moderate levels of negative heterosis were noted for S/P in each generation and each genotype. In the LMxR animals, estimates of the level of negative heterosis for S/P relative to the parental mean increased from the F_1 to F_4 generations. The negative heterosis supports the concept of recessive genes controlling follicle inheritance. Other workers have also generally found negative heterosis for follicle characterisitcs (Schinckel and Hayman, 1960; Pattie and Smith, 1964; McGuirk *et al.*, 1978). In the present data the F_2 generations had higher S/P and n(P+S) than the F_1. The increased values of these traits could be due to maternal effects of the crossbred dams.

Fleece Traits and Live Weight

In the LMxR flock, LWT and GFW increased in each generation with the maximum heterosis occurring in the F_4 generation. In contrast, in the SFMxR group LWT peaked in the F_1 while GFW reached a maximum in the F_4 animals. These results suggest a combination of heterosis, maternal effects and selection acting on these traits. Improved performance through adaptation to the grazing conditions at Tokanui may also be responsible. In contrast, for both genotypes, MFD remained lower than the parental mean [(R+M)/2], in both genotypes and all generations. The increased heterosis noted between the F_1 and F_2 generations,

TABLE 5 Estimates of heterosis by various methods using data corrected for age, year sampled and birth/rearing rank. Abbreviations for traits given in text.

Trait	Genotype	$F_1-\frac{(R+M)}{2}$	$F_2-\frac{(R+M)}{2}$	$F_3-\frac{(R+M)}{2}$	$F_4-\frac{(R+M)}{2}$
S/P	SFMxR	—2.37	—1.83	—1.36	—2.38
	LMxR	—2.37	— 2.25	— 2.13	— 3.67
n(P+S)	SFMxR	—4.37	— 0.92	— 0.30	— 0.19
	LMxR	—7.99	—10.76	—12.62	—17.33
nP	SFMxR	0.01	0.23	0.09	0.64
	LMxR	0.05	— 0.16	— 0.35	— 0.17
LWT (kg)	SFM XR	6.84	4.89	4.18	1.28
	LMxR	5.99	6.77	6.02	7.02
GFW (kg)	SFMxR	0.18	0.22	0.30	0.36
	LMxR	0.47	0.48	0.35	0.71
MFD (μm)	SFMxR	—2.44	— 2.74	— 3.37	— 3.17
	LMxR	—0.04	— 1.12	— 1.09	— 0.18
QN	SFMxR	0.40	— 0.61	— 0.04	— 1.24
	LMxR	—1.80	0.04	0.33	— 0.54
SL (cm)	SFMxR	—1.24	— 0.96	— 1.15	— 0.36
	LMxR	—0.87	— 0.19	— 0.82	— 1.01
TCN	SFMxR	0.99	1.23	4.41	4.52
	LMxR	0.99	1.75	1.64	2.45

especially for LWT and GFW may have been partly due to maternal effects. The F_1 dams of the F_2 animals may have provided a better maternal environment than that of the purebred dams.

CONCLUSION

The S/P follicle density increased with the proportion of Merino in the crossbred genotype. Interbred crossbreds weigh more and produce heavier, better quality fleeces than expected from the mid-parental averages.

ACKNOWLEDGEMENTS

Financial support was provided by a grant from the Ministry of Agriculture and Fisheries. The use of facilities of the Wool, Physiology and Anatomy and Animal Science Departments of Massey University is acknowledged.

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