Genetic variation among six strains of Romneys and Border Leicester and Coopworth crosses

R.L. BAKER AND J.N. CLARKE

Ruakura Animal Research Station
Ministry of Agriculture and Fisheries, Hamilton

H.H. MEYER

Department of Animal Science
Oregon State University, Corvallis, U.S.A.

T.G. HARVEY

Rotomahana Research Station
Ministry of Agriculture and Fisheries, Rotorua

M.L. BIGHAM

Whatawhata Hill Country Research Station
Ministry of Agriculture and Fisheries, Hamilton

ABSTRACT

The trial reported in this paper was undertaken at the Rotomahana Research Station to compare the performance of sheep of different genetic background and breeding history. Border Leicester, Coopworth and Romney rams from different sources were mated to Romney ewes representing a wide range of genetic sources between 1979 and 1983. Rams from 6 Romney strains were sampled including a commercial industry sample, the Ruakura High Fertility (RHF) flock, a Romney stud and 3 group breeding schemes. The Coopworth ram source was also a large group breeding scheme.

Data collected on the first cross females born between 1979 and 1983 and lambing between 1981 and 1985 are summarised in this paper. Analyses of ewe hogget performance (growth, wool production and oestrous activity) revealed relatively minor variation among the 6 Romney strains, with the exception of greater oestrous activity in RHF-sired hoggets. Coopworth and Border Leicester crosses were heavier, had higher fleece weights and showed more oestrous activity than straightbred Romneys.

Highest reproductive performance was obtained from Coopworth and Border Leicester crosses reflecting breed differences, positive heterosis and heavier ewe body weights. Among the 6 Romney strains greatest variation in reproductive performance was seen for litter size with the RHF-sired ewes excelling and also having the best performance for lambs weaned per ewe joined and lambs weaned per ewe joined as a ratio of ewe body weight. Similarly, the litter size advantage for ewes sired by rams from the 3 Romney group breeding schemes demonstrated that selection for reproductive performance over a period of 10 to 15 years has been successful.

Keywords Sheep; genetic variation; breeds; strains; growth; wool; reproduction.

INTRODUCTION

Extreme claims made as to the virtues of superior strains or types of sheep, are often based on limited or non-representative results. Of particular significance to the evolution of different strains of sheep is the variation which exists among studs or ram breeding flocks. Do they differ in the attention given in selection decisions to breeding value rankings based on measured performance for traits of economic importance? An increasing proportion of ram breeding flocks are giving genetic improvement considerable emphasis. For example, the co-operative group breeding schemes (Parker and Rae, 1982) make efforts to maximise selection intensity by deliberate widespread screening. The objective is to establish and continually replenish a specialised nucleus of high performing stock, from which future performance-recorded sires are bred. Very limited knowledge is available to document clearly the relative success of various breeding ventures (e.g. Clarke, 1978).

The trial reported here was initiated in 1979 at the Rotomahana Research Station to compare the performance of some New Zealand dual-purpose strains and breeds of sheep from different genetic backgrounds and breeding histories. The objective was not to rank individual studs or ram breeding sources but to provide information on the extent of

variation that exists among strains and among sire progeny groups within strains for the important components of production, namely growth, wool production and reproductive performance.

MATERIALS AND METHODS

Animals and Management

Border Leicester, Coopworth and Romney rams from different sources were mated to similar Romney ewes representing a wide range of genetic sources for 5 years (1979 to 1983) to compare offspring performance. Six Romney strains were evaluated including a commercial industry sample, the Ruakura High Fertility (RHF) flock (Clarke, 1972), a stud flock and 3 group breeding schemes. The Coopworth ram source was also a large group breeding scheme. The industry Romney rams and the Border Leicester rams were purchased by a stock firm as *good average flock rams* at the rate of 1 per breeder from as wide a range as possible of registered flocks throughout New Zealand, without access to performance records even if they were available, but avoiding any rams that were closely related. Representative rams from the other 6 sources were selected with access to records to avoid large deviations from average for lamb production, growth and wool production. Each source supplied 23 rams (5 per year from 1979 to 1982 and 3 in 1983) apart from 38 rams representing rams from the commercial Romney ram-breeding industry and 13 rams from the stud flock (1979 to 1981 only).

In 1982 and 1983 first-cross (F1) female offspring were mated to either rams of their own sire strain or to F1 sons of that strain. The result was contemporaneous F1, interbred (F2) and backcross progeny of each source to permit estimation of non-additive genetic effects. The performance of F1 female progeny only is presented in this paper.

Hogget oestrous activity was assessed by teaser rams over approximately a 4-month period from April to July (7 to 10 months of age).

Virtually all male progeny were castrated and not recorded after weaning, apart from the few F1 males left entire to generate F2 progeny. From 1984 onwards all ewes bred in the trial (F1, F2 and backcross) were mated mainly to Down rams to measure lifetime wool production, lifetime reproduction and lamb production when rearing crossbred lambs of high growth potential. Females bred in the trial were first joined at 19 months of age.

No culling on performance was carried out either among the ewe hoggets or during the evaluation of ewe performance. Except during the single-sire mating period each year, all ewes were given equal treatment by managing them together in large grazing groups to avoid management effects contributing to breed or strain differences.

Statistical Analysis

All hogget and ewe production traits were analysed by least-squares analysis of variance. A fixed-effect model was fitted which included year born (1979 to 1983), age of dam (2 to 5 year old), breed-strain (8), birth-rearing rank (single-single; multiple-multiple; multiple-single) and a covariate for birth date. Preliminary analyses fitted first-order interactions which were in general found to be not significant and were deleted from the model. Ewe production and production traits were analysed separately for each age at lambing (2 to 5 year old) by fitting a model which included year born, breed-strain and birth date, with least squares means summarised as a simple unweighted average across production ages.

Hogget fleece traits were available only for hoggets born 1979 to 1982. This data set was analysed using the same fixed-effect model as for the total data set. CIE Y-Z tristimulus values (Bigham *et al.*, 1984) were measured as an index of yellowness with the higher values indicating more discolouration.

RESULTS

Live weights of Border Leicester- and Coopworth-cross ewe hoggets tended to increase with age relative to the Romney. The difference was about 1 kg at weaning increasing to about 4 kg (8%) for Coopworth crosses and 7 kg (14%) for Border Leicester crosses by 16 months of age (Table 1), then stabilising at ewe weights which were higher by about 10% and 17% respectively at maturity (Table 5). There was relatively little variation in growth from birth to 16 months of age among the 6 Romney strains with the range being 2.3 kg (4.6%) at 16 months.

Greasy fleece weights of Coopworth- and Border Leicester-cross hoggets consistently exceeded the Romneys by about 10% at both the lamb and hogget shearing, with a range of only 0.16 kg (4.7%) among Romney strains for hogget fleece weight (Table 2). While there was significant variation among all 8 breed-strain groups for the 5 fleece traits shown in Table 2, the differences were quite small. Coopworth and Border Leicester-crosses had longer staple length and slightly coarser fleeces than the Romneys. Among the Romney strains the RHF-cross hogget fleeces had the shortest staple length, least yellow discoloration and highest loose wool bulk.

Hogget oestrous activity both in terms of incidence and number of teaser tuppings was highest in the RHF, Border Leicester and Coopworth sired ewe hoggets (Table 3). There was very little variation in either trait among the other 5 Romney strains.

As expected the Border Leicester and Coopworth crosses were more open-faced than the Romneys (Table 3). Among the Romney strains RHF-sired ewes were the most open-faced followed

TABLE 1 Least-squares strain and breed-cross means for live weight (kg) of F1 ewe hoggets. Number of observations in parenthesis.

Strain/breed of sire	Birth weight	Weaning weight (3 month)	Hogget weight (13 month)	Two-tooth weight (16 month)
Romney strains				
A — Industry	4.30 (317)	18.4	41.9	51.3 (255)
B — Stud	4.24 (256)	18.2	40.5	49.8 (230)
C — RHF[1]	4.22 (340)	18.4)	42.3	52.0 (286)
D — GBS[1]	4.32 (377)	18.6	41.7	50.8 (319)
E — GBS[1]	4.30 (379)	18.9	42.8	51.8 (305)
F — GBS[1]	4.31 (346)	18.6	42.9	52.1 (300)
Coopworth	4.30 (366)	19.3	45.6	55.2 (311)
Border Leicester	4.44 (367)	19.5	47.9	58.5 (326)
SED	0.05	0.3	0.4	0.5
Overall mean	4.30 (2748)	18.7	43.2	52.7 (2332)

[1] RHF Ruakura High Fertility; GBS Group breeding schemes.

TABLE 2 Least-squares strain and breed-cross means for fleece weight and fleece traits of F1 ewe hoggets.

Strain/breed of sire	Greasy lamb fleece weight (kg)	Greasy hogget fleece weight (kg)	Staple length (cm)	Washing yield (%)	Fibre diameter (μm)	CIE Y-Z value	Loose wool bulk (cm^3/g)
Romney strains							
A — Industry	1.26	3.53	14.0	76.5	33.7	3.13	20.5
B — Stud	1.23	3.39	14.2	77.9	33.8	3.06	19.6
C — RHF[1]	1.24	3.40	13.6	75.2	33.6	2.86	22.5
D — GBS[1]	1.28	3.48	14.2	76.1	33.7	3.17	20.5
E — GBS[1]	1.31	3.53	14.2	75.7	33.4	3.27	20.6
F — GBS[1]	1.29	3.55	14.2	75.8	33.4	3.19	20.4
Coopworth	1.38	3.93	15.1	75.0	34.9	3.26	20.6
Border Leicester	1.36	3.92	15.8	76.8	35.8	3.26	19.7
SED	0.02	0.04	0.2	0.5	0.2	0.08	0.2
Overall mean	1.29	3.59	14.4	76.1	34.0	3.15	20.5

[1] RHF Ruakura High Fertility; GBS Group breeding scheme.

TABLE 3 Least-squares strain and breed-cross means for oestrous activity and face cover scores of F1 ewe hoggets.

Strain/breed of sire	Incidence of oestrus (%)	Number of teaser tuppings	Face cover score[1] (1-7)
Romney strains			
A — Industry	49	0.9	2.4
B — Stud	54	1.0	2.6
C — RHF[2]	70	1.6	3.3
D — GBS[2]	57	1.0	2.9
E — GBS[2]	52	1.0	3.1
F — GBS[2]	53	1.0	3.1
Coopworth	62	1.3	3.9
Border Leicester	73	1.5	5.1
SED	4	0.1	0.1
Overall mean	59	1.2	3.3

[1] 1 Very woolly faced - 7 Very open faced.
[2] RHF Ruakura High Fertility; GBS Group breeding scheme.

by the ewes sired by rams from the 3 group breeding schemes.

Reproductive performance for F1 ewes lambing from 2 to 5 years of age is summarised in Table 4. The highest reproductive performance was obtained from Coopworth and Border Leicester crosses, with an advantage in litter size of 0.25 lambs born per ewe lambing relative to the Romney industry strain. Among the 6 Romney strains greatest variation was seen for litter size with the RHF-sired ewes excelling followed by the 3 group breeding schemes which were very similar in litter size. The range in litter size among Romney strains of 0.29 lambs born per ewe lambing is slightly larger than the advantage in litter size of the Coopworth and Border Leicester crosses over the Romney industry strain. The variation in either fertility or lamb survival among Romney strains was relatively small with ranges of 0.05 and 0.06 respectively. Among the 8 strain or breed-cross means there was a positive correlation ($r = 0.78$)

TABLE 4 Average least-squares strain and breed-cross means for F1 ewe reproduction over 2 to 5 years of age[1].

Strain/breed of Sire	No. of two-tooth ewes joined	Fertility[2] (EL/EJ)	Litter size[2] (LB/EL)	Lamb survival[2] (LW/LB)
Romney strains				
A — Industry	249	0.88	1.45	0.81
B — Stud	232	0.87	1.39	0.78
C — RHF[3]	288	0.91	1.68	0.82
D — GBS[3]	316	0.88	1.57	0.84
E — GBS[3]	310	0.89	1.59	0.83
F — GBS[3]	301	0.92	1.57	0.81
Coopworth	312	0.91	1.70	0.83
Border Leicester	317	0.93	1.71	0.87
SED[4]	—	0.03	0.05	0.03
Total or overall mean	2325	0.90	1.58	0.82

[1] Average of least squares means involving a total of 2325 2-year-old ewe joinings (born 1979-83), 1931 3-year-old (born 1979-82), 1455 4-year-old (born 1979-81) and 1041 5-year-old ewe joinings (born 1979-80).
[2] EJ Ewes joined; EL Ewes lambing; LB Lambs born; LW Lambs weaned.
[3] RHF Ruakura High Fertility; GBS Group breeding scheme.
[4] Approximate estimate.

TABLE 5 Average least-squares strain and breed-cross means for F1 ewe production over 2 to 5 years of age (refer Table 4).

Strain/breed of sire	Greasy fleece weight (kg)	Live weight (kg)	Weaning rate[1] (LW/EJ)	Productivity[2] (%)
Romney strains				
A — Industry	4.5	57.3	1.01	100
B — Stud	4.4	55.6	0.94	96
C — RHF[3]	4.2	58.6	1.23	119
D — GBS[3]	4.3	57.0	1.16	115
E — GBS[3]	4.4	58.0	1.16	114
F — GBS[3]	4.4	58.9	1.14	110
Coopworth	4.9	63.1	1.27	114
Border Leicester	4.8	67.5	1.36	114
Overall mean	4.5	59.5	1.16	

[1] LW Lambs weaned; EJ Ewe joined.
[2] Weaning rate as a ratio of ewe live weight expressed relative to the industry Romney strain.
[3] RHF Ruakura High Fertility; GBS Group breeding scheme.

between litter size and lamb survival, in contrast to the negative phenotypic association commonly found among ewes within a flock or strain.

Some other aspects of ewe production are summarised in Table 5. Strain and breed-cross variation for ewe live weight and greasy fleece weight followed very closely the rankings at the hogget stage. Overall reproductive performance is reported in terms of weaning rate (lambs weaned per ewe joined), which combines the 3 component reproductive traits shown in Table 4. Relative to the Romney industry strain the Coopworth and Border Leicester crosses weaned an extra 0.26 and 0.35 lambs per year respectively, closely followed by the RHF-sired ewes which weaned an additional 0.22 lambs per year. The 3 group breeding schemes were similar in weaning rate and weaned an additional 0.15 lambs per ewe per year relative to industry Romney crosses.

A close relationship between ewe weight and reproductive performance (particularly litter size and weaning rate) has been commonly reported (e.g. Clarke and Meyer, 1982). At least part of the superior reproductive performance of the Coopworth and Border Leicester crosses was related to their heavier live weights compared with the Romneys. A simple approach to adjust for ewe live weight is shown in Table 5 by taking weaning rate as a ratio of ewe live weight (productivity). On this basis the Coopworth and Border Leicester advantage in reproductive performance is reduced by about a half to 14% above the Romney industry strain, and becomes similar to the productivity of the Romney group breeding schemes. The outlier, as in previous reports (Clarke and Meyer, 1982), is the RHF-sired ewes with a 19% superiority in lamb output per unit of ewe live weight.

DISCUSSION

Considerable research effort has been devoted to experimental evaluation of breeds and crosses of sheep (Clarke, 1982; Clarke and Meyer, 1982). The study reported here is the first to evaluate the performance of a number of different strains of Romney, the predominant sheep breed in New Zealand. There are important genetic differences among Romney strains for reproductive performance. For some reproductive traits (litter size and weaning rate), these differences are as large as genetic differences among some of the sheep breeds presently farmed in New Zealand (Clarke and Meyer, 1982).

Among the 6 Romney strains evaluated the RHF-sired ewes excelled for litter size and also had the highest weaning rate. Twice the litter size difference between the RHF- and commercial industry crosses (0.46) is in line with the cumulative response for litter size achieved in the parental flock over 24 years of selection solely for that trait (Clarke, 1972, 1978). Similarly, the litter size advantage for ewes sired by rams from the 3 Romney group breeding schemes evaluated in this study indicates a cumulative average genetic superiority over commercial industry Romneys of 0.26 in litter size

and 0.30 in weaning rate. This demonstrates that selection for reproductive performance, in conjunction with other traits of economic importance (growth and wool production) has, in these group breeding schemes over a period of some 10 to 15 years, been successful. The 3 Romney group breeding schemes represented, which are some of the largest and longest established schemes presently operating in New Zealand (the New Zealand Romney Development Group, the Wairarapa Romney Improvement Group and the Landcorp Waihora group breeding scheme) all performed at very similar levels.

In contrast to the significant genetic differences among Romney strains for reproductive performance, the differences for other production characteristics such as growth and wool production were quite small. This result is in contrast to differences among strains of Merinos evaluated in a large, comprehensive trial in Australia which have been most marked for wool production characteristics and live weight (Atkins, 1979) reflecting the different selection emphasis in the 2 countries.

Coopworth and Border Leicester rams were included in this study to represent alternative sources of rams for the commercial Romney breeder who wishes to increase dual-purpose sheep production. First-cross Border Leicester x Romney sheep are expected to benefit from the documented genetic superiority of the Border Leicester over the Romney for reproductive performance and from positive heterosis in this cross (Clarke and Meyer, 1982). Both these effects are presumably reflected in the superior performance demonstrated for reproductive performance, growth and wool production. How much of this superiority is maintained in F2 crosses and backcrosses to the sire breed will be reported in subsequent papers once further data become available.

Based on a summary of many New Zealand trials, Smeaton *et al.* (1985) concluded that the Coopworth out-performed the Romney in most production traits with the exception of wool production. The results here cannot yet be directly compared to those trials since purebred Coopworths and Romneys were compared *v* Coopworth x Romney and purebred Romneys in the present study. In addition to possible favourable heterosis effects, the Coopworth group breeding ram source sampled here (formerly the Apex group) may be genetically superior to Coopworth rams evaluated in earlier trials. Again, final resolution of this question must await analysis of the F2 and backcross sheep.

The performance of F1 ewe progeny sired by the different Romney ram sources could include a heterotic component. This is most likely for the RHF-sired progeny where it is known that the RHF parental flock is quite inbred (Clarke, 1978). However, heterosis among the other Romney strains should not be dismissed, especially in light of the interesting finding that heterosis among Merino strains may be comparable to that which exists among diverse breeds of sheep (Atkins, 1987).

ACKNOWLEDGEMENTS

To the breeders who provided rams for this trial; to the staff of the Rotomahana Research Station for management of the trial and recording data; to J.L. Dobbie for assistance in initiating the trial and annual wool sampling; to A.P. Hurford for management and analysis of the large data sets.

REFERENCES

Atkins K.D. 1979. Variation between strains and between flocks within strains of Merino sheep. *Proceedings of the Australian Association of Animal Breeding and Genetics* **1:** 45-46.

Atkins K.D. 1987. Heterosis among Merino strains and bloodlines. *Proceedings of the Australian Association of Animal Breeding and Genetics* **6:** 293-295.

Bigham M.L.; Sumner R.M.W.; Cox N.R. 1984. Sources of variation and experimental design criteria for wool colour measurement applied to Romney, Coopworth and Perendale breeds. *New Zealand journal of agricultural research* **12:** 231-236.

Clarke J.N. 1972. Current levels of performance in the Ruakura fertility flock of Romney sheep. *Proceedings of the New Zealand Society of Animal Production* **32:** 99-111.

Clarke J.N. 1978. Romney sheep; Highly selected versus industry animals. *Proceedings of the Ruakura farmers' conference* **30:** 6-9.

Clarke J.N. 1982. The utilisation of breed resources in the improvement of sheep productivity. *Proceedings of the 2nd World Congress on Genetics Applied to Livestock Production* Madrid. **5:** 635-654.

Clarke J.N.; Meyer H.H. 1982. Implications of experimental results in the crossbreeding of sheep in New Zealand. *Proceedings of the World Congress on Sheep and Beef Cattle Breeding.* Eds. R.A. Barton and W.C. Smith. **1:** 133-146.

Parker A.G.H.; Rae A.L. 1982. Underlying principles of co-operative group breeding schemes. *Proceedings of the World Congress on Sheep and Beef Cattle Breeding* Eds. R.A. Barton and W.C. Smith. **2:** 95-101.

Smeaton D.; Scobie G.M.; Bywater A.C.; Hockey H-U.P.; Davis G.H. 1985. Sheep — Romneys, Coopworths, Perendales — Comparison of the three main breeds. *Proceedings of the Ruakura farmers' conference* **37:** 30-35.