Evaluation of the Finnish Landrace × Merino and Merino as dam lines in crosses with five sire lines: slaughter and carcass traits of ram lambs

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Carcasses of 122 ram lambs born from Finnsheep × Merino (FM) and Merino (ME) as dam lines, crossed with the Ile de France (IF), SA Mutton Merino (SAMM), Döhne Merino (DM), FM and Merino as sire lines were evaluated for meat production. Significant differences ($P < 0,05$) were found between sire lines and between dam lines for warm carcass mass, dressing percentage, subcutaneous fat, omentum fat, percentage lean, carcass length and conformation. Sire breeds differed significantly ($P < 0,05$) from each other in respect of bone, kidney knob channel fat, length of the hind limb, fat thickness at the third lumbar vertebrae, area of the eye muscle and mass of the liver, while dam lines differed significantly ($P < 0,05$) for fat score. Lambs born from the Merino sire, had a significantly ($P < 0,05$) lower dressing percentage, a lower warm carcass mass and more subcutaneous fat than lambs from the other sire lines. Lambs born from the FM dam line had significantly ($P < 0,05$) less subcutaneous fat and significantly ($P < 0,05$) more intra-abdominal fat than lambs from the Merino dam line. No significant differences were found between sire lines or between dam lines for total carcass fat, muscular fat or carcass protein. Results suggest that carcass traits differ relatively little between the two dam and also between the five sire lines. The optimum slaughter mass for all genotypes lies at about 40 kg live mass.

Karkasse van 122 ramlammers gebore uit die Finse Landras × Merino (FM) en die Merino (ME) as moederlyne, gekruis met die Ile de France (IF), SA Vleismerino (SAMM), Döhne Merino (DM), FM en Merino as vaderlyne, is geëvalueer ten opsigte van vleisproduksie. Betekenisvolle verskille is tussen vaderlyne en tussen moederlyne gevind vir warm karkasmassa, uitslagpersentasie, onderhuidse vet, persentasie vleis, omentumvet, karkaslengte en konformasie. Vaderlyne het betekenisvol ($P < 0,05$) van mekaar verskil ten opsigte van been, nier- en kanaalvet, boudlengte, vetdikte by die derde lumbale werwel, oogspieroppervlakte en massa van die lewer, terwyl moederlyne betekenisvol ($P < 0,05$) verskil het ten opsigte van vettelling. Lammers gebore van die Merinovaderlyn het 'n betekenisvolle ($P < 0,05$) laer uitslagpersentasie, laer warm karkasmassa, en meer onderhuidse vet as die lammers van ander vaderlyne gehad. Die FM-moederlyn se nageslag het betekenisvol ($P < 0,05$) minder onderhuidse vet en betekenisvol ($P < 0,05$) meer intra-abdominale vet as die Merino-moederlyn se nageslag gehad. Geen betekenisvolle verskille is tussen vader- of tussen moederlyne vir totale karkasvet, spiervet of karkasproteïen gevind nie. Resultate dui aan dat karkaseienskappe tussen die twee ooi- en tussen die vyf ramlyne relatief min verskil. Optimum slagpunt van die verskillende genotipes lê by ongeveer 40 kg lewende massa.

Keywords: Crossbreeding, sheep, slaughter and carcass traits.

Introduction

The success of any intensive sheep production system depends largely on the number of high quality carcasses which can be produced from a given number of ewes. In order to increase meat production, all possible sources of variation should be exploited. One such possibility is the the use of specialized sire and dam lines, as shown by Smith (1964). Substantial benefits manifested as positive heterosis can be obtained by utilizing differences between breeds.

Breeds differ in carcass composition, especially in fat content at the same live mass (Casey, 1982). Carcass fat content is a major factor in determining the grading and thus affecting the economic value of the carcass. Therefore, selecting suitable breeds for producing carcasses with an optimum amount of subcutaneous fat is an important factor to be considered in a commercial crossbreeding system.

The shortage of suitable dam lines for meat production under intensive conditions in South Africa, has focused attention on the Finnsheep. This breed has been used worldwide in crosses to improve reproduction of local breeds. The relatively high reproduction rate of the Finnsheep × Merino (FM) compared to that of the Merino, makes the FM genotype a more suitable dam line for the production of slaughter lambs under intensive conditions (Greeff *et al.*, 1990; Hofmeyr, 1980). The usefulness of this genotype, however, also depends on its effects on growth rate and carcass traits of the crossbred lambs. Crosses based on the Finn showed a higher lamb mortality and a slower growth rate than the British meat breeds (Donald *et al.*, 1968). Greeff *et al.* (1989), however, showed that crossbred lambs born from Finn × Merino ewes had a higher growth rate than lambs born from the Merino. In respect of carcass traits, McClelland & Russell (1972), Boylan *et al.* (1976), and Dickerson (1977) showed that the FM genotype deposits less fat subcutaneously and relatively more fat intra-abdominally than other breeds. This may make a valuable contribution in the production of leaner carcasses and therefore may have an effect on the optimum slaughter mass of lambs produced from Finnsheep genotypes.

The Merino is presently the major sheep breed in South Africa and Merino ewes are sometimes used as a dam line in crosses with white-woolled mutton breeds, viz. the Ile de France (IF), SA Mutton Merino (SAMM), and Döhne Merino (DM), which are commonly used for the production of slaughter lambs. This study reports on differences in carcass traits of

ram lambs born to five sire lines to determine the potential of these breeds as possible terminal sires. The aim of this study was, secondly, to evaluate the effect of Finnsheep × Merino and Merino dam lines, crossed with the five sire lines, on carcass characteristics of the progeny, to determine whether the Finnsheep × Merino dam has more of a negative effect on the carcasses of the lambs when compared to using the Merino as a dam line. Thirdly, growth patterns of different tissues were studied to determine the optimum slaughter point for each genotype. Different maturity types or physiological groups were not taken into consideration in this study.

Material and Methods

Animals

One hundred and twenty-two ram lambs, born from Finnsheep × Merino (FM) and Merino (ME) dam lines, crossed with the Ile de France (IF), SA Mutton Merino (SAMM), Döhne Merino (DM), FM and Merino (ME) were used in this experiment. Eleven IF, 13 SAMM, 12 Merino, 25 FM and four DM rams were used to represent the different sire breeds. The preweaning survival and growth rates of these lambs under range conditions were discussed by Greeff *et al.* (1989). Lambs were born during March and April 1985 and weaned at approximately 100 days of age. Only singles were selected for this experiment, but where inevitable, twins raised as singles were used. Lambs were transported by train from the Eastern Cape to the Animal and Dairy Science Research Institute at Irene, when they had a body mass of between 18 and 20 kg.

Management and housing

After arrival, lambs were adapted over a period of two weeks on a complete pelleted diet as indicated in Table 1, and were housed in three adjacent pens where the diet was available *ad libitum.*

Table 1 Composition of the diet (air-dry basis)

Lucerne hay	50%
Maize meal	38%
Fish-meal	10%
Monosodium phosphate	1%
Calcium carbonate	0,5%
Salt	0,5%
Vitamins and minerals[a]	0,1%
Crude protein	16,2% in DM
Metabolizable energy	9,4 MJ/kg DM

[a] Commercial mixture.

Design

The treatment design was a 2 × 5 factorial with unequal cell frequencies. Unequal cell numbers were caused by the fact that only 125 ram lambs were available. Furthermore, apart from three deaths, different numbers of lambs were available for each cross, resulting in different numbers of lambs per genotype in the experiment. Lambs were randomly allocated for slaughter at respectively 22, 31, 40 or 49 kg live mass in order to study growth patterns of different tissues over a wide range of live masses to determine the optimum slaughter point for each genotype. Table 2 indicates the distribution of lambs slaughtered at different live masses for each genotype.

Table 2 Number of animals slaughtered at different live masses

	Slaughter mass (kg)				
Genotype[a]	22	31	40	49	Total
DM × FM	2	3	3	2	10
DM × ME	3	3	4	3	13
FM × FM	4	3	3	3	13
FM × ME	3	3	4	2	12
IF × FM	4	5	4	3	16
IF × ME	3	3	3	2	11
ME × FM	1	3	2	3	9
ME × ME	2	2	3	2	9
SAMM × FM	3	5	4	4	16
SAMM × ME	3	3	4	3	13
					122

[a] DM = Döhne Merino; FM = Finn × Merino; IF = Ile de France; ME = Merino; SAMM = SA Mutton Merino.

Slaughter procedure

Lambs were not sheared prior to slaughter and were slaughtered by cutting the jugular vein, and were skinned in the usual way. Following slaughter, carcasses were prepared in the normal commercial manner and hung overnight at ambient temperature (± 4 °C). After visual assessment of fatness, carcasses were scored according to the Meat Grading Regulations (Marketing Act, 1968; Act 59 of 1968) and split medially down the back. Carcass length was measured from the head of the humerus to the *Trochanter major* of the femur, while length of the hind limb was measured between the *Trochanter major* of the femur to the anterior of the tarsus. The area of the *M. Longissimus dorsi*, henceforth referred to as the eye muscle area, was determined by multiplying the width and length of the muscle at the 13th thoracic vertebra. Fat C was measured as the subcutaneous fat thickness on the midline between the 9th and 10th rib while Fat B was measured as the subcutaneous fat thickness, 25 mm laterally off the same point off the midline. Lumbar fat was measured between the 3rd and 4th lumbar vertebrae, 50 mm off the midline. Dressing percentage was defined as cold carcass mass, including kidneys and kidney knob channel fat (KKCF), divided by live empty body mass (LEBM). Conformation was defined as the ratio, carcass mass/carcass length (Bruwer, 1984).

The KKCF was removed from one side of the carcass and this side of each carcass was dissected into five anatomical joints, i.e. neck, fore limb, ventral trunk, dorsal trunk and hind limb (Casey, 1982). Each joint was dissected into subcutaneous fat (SCF), 'lean' and bone, where 'lean' consists of muscle, intramuscular fat, intermuscular fat and associated tissues. After dissection, the dissected 'lean' and subcutaneous fat of the joints were pooled, minced and the moisture content

was determined on a representative wet sample. A representative sample was freeze-dried and analysed chemically for nitrogen, ether extract and ash on an absolute dry basis. These values were then converted into a wet basis using the moisture value determined on the wet sample. The nitrogen (wet basis) was then multiplied by 6,25 to determine protein (AOAC, 1970). This value was added to moisture and ash and the sum was regarded as 'muscle' and the ether extract as 'fat'. The percentage muscle and percentage fat was then used to calculate the mass of muscle and fat in the mass of the dissected meat and subcutaneous fat of the five joints which had been added together. The calculated masses of the muscle and fat as well as the dissected mass of the bone were then used to calculate the percentage muscle, fat and bone in the side to give a reliable estimate of the composition of the carcass, excluding KKCF.

Statistical analysis

Data were analysed with the LSML76 computer program of Harvey (1987) to determined whether significant differences exist between sire and between dam lines for slaughter and carcass traits and, secondly, to determine whether significant differences exist between deposition rates as measured by the regression coefficients over the range of slaughter masses. Two analyses were carried out.

In the analysis of slaughter data, mass of the liver, skin, head and trotters, heart and lungs, stomach and intestines, omentum fat, dressing percentage and age at slaughter were defined as dependent variables against live empty body mass (LEBM) as independent variable for the calculation of individual class regression coefficients of slaughter traits. In the analysis of carcass data, eye muscle area, percentage dissected lean, SCF and bone, kidney knob channel fat (KKCF), subjective fat score, Fat C, Fat B, lumbar fat, total chemical fat, percentage muscle, fat and bone calculated from the chemical composition of the carcass, carcass length, length of the hind leg and conformation, were defined as dependent variables against cold carcass mass as independent variable for the calculation of regression coefficients of carcass traits.

The following model was used:

$$Y_{ijk} = \mu + a_i + c_j + ac_{ij} + bX_{ijk} + e_{ijk}$$

where

Y_{ijk} = the observed value of a given dependent variable,

μ = the overall mean,

a_i = the fixed effect of the i-th sire breed,

c_j = the fixed effect of the j-th dam breed,

ac_{ij} = the sire × dam breed interaction,

b = the regression of Y_{ijk} on live empty body mass as independent variable in the analysis of slaughter traits, or cold carcass mass as independent variable in the analysis of carcass traits,

X_{ijk} = live empty body mass or cold carcass mass, and

e_{ijk} = the random error.

Linear contrasts and tests of significance were also calculated with Harvey's (1987) program to determine whether significant differences exist between sire and between dam lines. Where significant interactions between main effects were found, a different analysis was carried out with genotype as the only main effect to obtain regression coefficients of individual classes. This was done since the available statistical package could not compute the regression coefficients in such cases. Standard errors of predictions from the regression were calculated according to the formula given by Steel and Torrie (1981).

Results

The overall means, error standard deviations, coefficient of variations and multiple correlation coefficient (R^2 values) of all traits are indicated in Table 3.

Table 3 Overall means, error standard deviations, coefficient of variation (%) and R^2 values of all traits

Trait	Mean	*SD*	CV (%)	R^2
Liver (kg)	0,72	0,070	9,71	0,903
Skin (kg)	3,87	0,522	13,49	0,920
Head & trotters (kg)	2,84	0,181	6,38	0,951
Heart & lungs (kg)	1,59	0,187	11,80	0,856
Stomach & intest (kg)	3,44	0,431	12,56	0,720
Omentum fat (kg)	0,43	0,154	36,19	0,817
Dressing %	52,87	2,162	4,09	0,393
Age at slaughter (d)	173,42	40,890	23,57	0,825
Eye muscle area (mm^2)	1252,64	1,364	1,09	0,849
Chemical composition				
Muscle (%)	67,20	3,830	5,70	0,152
Fat (%)	15,46	3,536	22,86	0,432
Bone (%)	17,33	2,461	14,20	0,439
Dissected composition				
Lean (%)	78,46	2,436	3,10	0,314
SCF (%)	4,16	1,401	33,77	0,801
Bone (%)	17,38	2,423	13,93	0,450
Total chemical fat (kg)	2,36	0,544	23,06	0,831
KKCF (%)	3,50	1,129	32,23	0,568
Fat score	2,39	0,549	22,90	0,713
Fat C (mm)	3,98	1,471	36,95	0,625
Fat B (mm)	3,28	1,246	37,91	0,605
Lumbar fat (mm)	4,74	1,884	39,76	0,637
Carcass length (cm)	58,05	1,679	2,89	0,903
Length of leg (cm)	37,08	1,100	2,97	0,834
Conformation (kg/cm)	2,55	0,309	12,14	0,819
Live empty body mass (kg)	28,33			
Cold carcass mass (kg)	15,07			

From Table 3 it is clear that fat is the most variable component of the carcass. In most cases, the model accounted for more than 60% of the total variation as indicated by the R^2 values. In the case of dressing percentage, percentage fat, percentage bone and percentage lean, the model accounted for less than 50%, and only about 15% of the total variation for percentage muscle, respectively.

Levels of significance for differences between the intercepts of groups and between regression coefficients of the different groups for slaughter traits are indicated in Table 4. Table 5

Table 4 *F* values for slaughter traits

Source	df	Skin mass	Head and trotters	Liver	Heart and lungs	Dressing %	Stomach and intestines	Omentum fat	Age at slaughter
Adjusted means (intercepts)									
Sire line	4	6,8***	11,5***	4,5***	1,9	1,1***	1,1	8,6***	3,3**
Dam line	1	29,4***	15,7***	0,0	0,1	7,7***	3,4*	7,9***	27,0***
Sire × dam	4	0,5	2,2	3,2**	1,8	1,1	0,7	2,2*	0,4
Regression									
Common slope	1	1042,4***	1882,8***	889,5***	575,3***	3,1	230,1***	365,1***	425,6***
Heterogeneity									
Sire line	4	2,5**	9,1***	1,2	0,5	0,8	1,7	3,4***	3,7**
Dam line	1	5,4**	2,3	0,8	0,4	0,7	1,7	8,8***	1,8

* $P < 0,10$; ** $P < 0,05$; *** $P < 0,01$.

Table 5 Least square means ± standard errors and regression coefficients of sire and dam lines for slaughter traits, with LEBM as independent variable

Slaughter trait	Sire lines					Dam lines		Pooled value
	DM	ME	IF	SAMM	FM	ME	FM	
Skin mass (kg)	4,1 ± 0,11^{a}	4,2 ± 0,13^{a}	3,8 ± 0,10^{bc}	3,5 ± 0,09^{b}	4,0 ± 0,10^{ac}	4,2 ± 0,07^{1}	3,7 ± 0,07^{2}	–
Head and trotters (kg)	2,8 ± 0,04^{a}	3,0 ± 0,04^{b}	2,7 ±0,04^{a}	2,8 ± 0,03^{a}	2,8 ± 0,04^{a}	2,9 ± 0,02^{1}	2,8 ± 0,02^{2}	–
Liver (kg)	0,72 ±0,014^{ab}	0,68 ± 0,017^{a}	0,69 ± 0,013^{a}	0,76 ± 0,013^{cb}	0,72 ± 0,014^{ab}	0,71 ± 0,009	0,71 ± 0,009	–
Heart and lungs	1,59 ± 0,018	1,59 ± 0,018	1,59 ± 0,018	1,59 ± 0,018	1,59 ± 0,018	1,59 ± 0,018	1,59 ± 0,018	1,59 ± 0,018
Dressing %	52,3 ± 0,45^{a}	50,4 ± 0,52^{b}	54,3 ± 0,42^{c}	53,9 ± 0,40^{c}	52,0 ± 0,43^{a}	52,0 ± 0,29^{1}	53,1 ± 0,28^{2}	–
Stomach + intest (kg)	3,41 ± 0,09	3,36 ± 0,10	3,4 ± 0,08	3,57 ± 0,08	3,38 ± 0,09	3,35 ± 0,05^{1}	3,50 ± 0,056^{2}	3,42 ± 0,040
Omentum fat (kg)	0,48 ± 0,033^{ac}	0,45 ± 0,048^{a}	0,34 ± 0,30^{b}	0,35 ± 0,028^{b}	0,55 ± 0,031^{c}	0,39 ± 0,021^{1}	0,47 ± 0,020^{2}	–
Age at slaughter (d)	183,2 ± 3,66^{a}	172,8 ± 4,26^{ac}	169,0 ± 3,45^{bc}	167,2 ± 3,26^{b}	176,8 ± 3,49^{ac}	182,2 ± 2,31^{1}	165,4 ± 2,26^{2}	–
Regression coefficients								
Skin mass (kg)	0,187 ± 0,012^{a}	0,177 ± 0,016^{ab}	0,180 ± 0,012^{ab}	0,155 ± 0,011^{b}	0,206 ± 0,012^{ac}	0,194 ± 0,008^{1}	0,168 ± 0,008^{2}	–
Head and trotters (kg)	0,072 ± 0,004^{a}	0,100 ± 0,005^{b}	0,074 ± 0,004^{a}	0,074 ± 0,004^{b}	0,096 ± 0,004^{b}	0,086 ± 0,003	0,080 ± 0,003	–
Liver (kg)	0,019 ± 0,002	0,023 ± 0,002	0,024 ± 0,002	0,023 ± 0,001	0,023 ± 0,002	0,022 ± 0,001	0,023 ± 0,001	0,022 ± 0,001
Omentum fat (kg)	0,034 ± 0,004^{a}	0,032 ± 0,005^{ab}	0,024 ± 0,004^{b}	0,028 ± 0,003^{ab}	0,041 ± 0,003^{a}	0,027 ± 0,002^{1}	0,037 ± 0,002^{2}	–
Heart and lungs (kg)	0,043 ± 0,004	0,048 ± 0,006	0,052 ± 0,004	0,050 ± 0,004	0,049 ± 0,004	0,050 ± 0,003	0,047 ± 0,003	0,048 ± 0,002
Dressing %	0,063 ± 0,051	0,080 ± 0,064	−0,005 ± 0,049	0,078 ± 0,045	−0,011 ± 0,048	0,061 ± 0,033	0,021 ± 0,032	0,041 ± 0,023
Stomach + intest (kg)	0,083 ± 0,010	0,060 ± 0,013	0,078 ± 0,010	0,078 ± 0,009	0,053 ± 0,010	0,064 ± 0,007	0,076 ± 0,006	0,070 ± 0,005
Age at slaughter (d)	0,425 ± 0,041^{a}	0,483 ± 0,052^{c}	0,313 ± 0,041^{c}	0,336 ± 0,036^{c}	0,479 ± 0,038^{a}	0,432 ± 0,026	0,382 ± 0,025	–

Means with the same superscript in the same row do not differ significantly from each other.

indicates the least square means, defined as the best estimate of the effect of a treatment factor in an unbalanced design by the method of least squares, the standard errors of the least square means and regression coefficients of slaughter traits.

Highly significant differences ($P<0,01$) were found between sire lines for slaughter traits, except for the heart and lungs, and stomach and intestines (Table 4). Differences between sire lines for age at slaughter, were brought about because lambs from the DM sire line were slaughtered at an average age of 183,2 days, while lambs of the SAMM sire line were on average slaughtered at 167 days of age. No significant differences were found between the other sire lines for age at slaughter. Lambs born from the FM dam line were slaughtered on average 17 days ($P<0,01$) earlier than lambs of the ME dam line.

Significant aifferences ($P<0,01$) were found between some sire and between the dam lines for skin mass. Regression coefficients of mass of the skin against LEBM also differed significantly ($P<0,05$) between some sire and between the dam lines. The FM sire line had the largest regression coefficient of 0,206, which was significantly ($P<0,05$) higher than the regression coefficient of 0,155 of the SAMM sire line. Although the regression coefficient of the Merino did not differ significantly from that of the SAMM and IF, the Merino had a significantly ($P<0,01$) heavier skin than the SAMM and IF sire lines, while the values of DM, Merino and FM did not differ significantly from each other. Dam lines showed the same tendency with the Merino having a significantly ($P<0,01$) heavier skin but also a significantly ($P<0,05$) higher regression coefficient than the FM dam line.

Significant differences ($P<0,05$) were found between sire lines and between dam lines for head and trotters. The Merino sire and dam lines had significantly ($P<0,01$) heavier head and trotters than the other sire lines and the FM dam line (Table 5). Both the Merino and FM sire lines had significantly ($P<0,01$) higher regression coefficients of head and trotters against LEBM than the other sire lines, while the regression coefficients of the dam lines did not differ significantly from each other.

No significant differences were found between genotypes for heart and lungs, but the FM dam line had a slightly heavier ($P<0,10$) stomach and intestines (150 g) than the Merino dam line. A significant sire × dam interaction was found for omentum fat ($P<0,10$) and liver ($P<0,05$). The least square means and regression coefficients of the liver mass and omentum fat of the individual crosses were therefore determined in a separate analysis and are indicated in Table 6.

The significant sire × dam interaction for liver mass and omentum fat occurred, because the differences between average liver mass of the sires were not the same for both dam lines. The significant ($P<0,05$) lower regression coefficient of liver mass against LEBM of the DM × ME cross compared to the other genotypes is unclear, and no explanation for these interactions can be offered at this stage.

In respect of omentum fat, it would appear as if the FM dam line deposited more omentum fat than the ME dam line as indicated by the significantly ($P<0,05$) higher regression coefficients of the FM dam line, resulting in the FM dam line having significantly ($P<0,01$) more omentum fat than the ME dam line. Large differences in the average amount of omentum

Table 6 Least square means (± *SE*) and regression coefficients of liver mass and omentum fat on LEBM for the different genotypes

Genotype[1]	Carcass trait	LS Mean ± *SE* (kg)	Regression coefficient
DM × ME	Liver mass	0,71 ± 0,02^{abc}	0,014 ± 0,002^{a}
DM × FM	Liver mass	0,74 ± 0,02^{bc}	0,026 ± 0,002^{b}
ME × ME	Liver mass	0,72 ± 0,02^{abc}	0,024 ± 0,003^{b}
ME × FM	Liver mass	0,65 ± 0,02^{a}	0,022 ± 0,003^{b}
IF × ME	Liver mass	0,66 ± 0,02^{a}	0,023 ± 0,002^{b}
IF × FM	Liver mass	0,72 ± 0,02^{abc}	0,024 ± 0,002^{b}
SAMM × ME	Liver mass	0,77 ± 0,02^{c}	0,023 ± 0,002^{b}
SAMM × FM	Liver mass	0,74 ± 0,02^{bc}	0,022 ± 0,002^{b}
FM × ME	Liver mass	0,73 ± 0,02^{bc}	0,024 ± 0,002^{b}
FM × FM	Liver mass	0,71 ± 0,02^{abc}	0,022 ± 0,002^{b}
DM × ME	Omentum fat	0,45 ± 0,04^{bc}	0,029 ± 0,005^{b}
DM × FM	Omentum fat	0,51 ± 0,05^{ab}	0,039 ± 0,006^{ab}
ME × ME	Omentum fat	0,39 ± 0,05^{bc}	0,022 ± 0,006^{b}
ME × FM	Omentum fat	0,51 ± 0,05^{ab}	0,044 ± 0,007^{a}
IF × ME	Omentum fat	0,34 ± 0,05^{c}	0,023 ± 0,004^{b}
IF × FM	Omentum fat	0,34 ± 0,04^{c}	0,027 ± 0,005^{b}
SAMM × ME	Omentum fat	0,35 ± 0,04^{c}	0,024 ± 0,005^{b}
SAMM × FM	Omentum fat	0,35 ± 0,04^{c}	0,031 ± 0,004^{b}
FM × ME	Omentum fat	0,44 ± 0,04^{bc}	0,030 ± 0,005^{b}
FM × FM	Omentum fat	0,66 ± 0,04^{a}	0,049 ± 0,004^{a}

[1] Sire breed mentioned first.

$^{a-c}$ Means with the same superscript in the same column do not differ significantly from each other.

fat were also found between the Merino and the IF and SAMM sire lines. The IF and SAMM sire lines had significantly ($P<0,05$) less omentum fat than the Merino sire line, owing to their lower deposition rate as can be seen from their respective lower regression coefficients.

Dressing percentage differed significantly ($P<0,01$) between some sire and between dam lines. The SAMM and IF sire lines had significantly ($P<0,01$) higher dressing percentages, respectively 53,9 and 54,3%, than the other sire lines. The Merino sire line had the lowest dressing percentage of 50,4%, with the FM and DM intermediate with dressing percentages of 52,0 and 52,3%, respectively.

Table 7 indicates levels of significance for carcass traits. Significant differences were found between sire lines for eye muscle area ($P<0,05$), percentage lean ($P<0,01$), percentage SCF ($P<0,01$), percentage KKCF ($P<0,01$), carcass length ($P<0,01$), length of hind leg ($P<0,05$), conformation ($P<0,01$) and lumbar fat ($P<0,05$). No significant differences were found between sire lines for the chemical components of the carcass (muscle, fat and bone), percentage dissected bone, total carcass fat, fat score, Fat C and Fat B. Dam lines differed significantly only in respect of percentage SCF ($P<0,01$), percentage lean ($P<0,05$), fat score ($P<0,05$), carcass length ($P<0,05$), length of leg ($P<0,10$) and conformation ($P<0,05$).

Except for bone, the relationship between the chemical and the dissected components of the carcass (muscle vs. lean and

Table 7 *F* values for carcass traits

Source	df	Eye muscle area	Dissected components			Chemical components			Total fat	KKCF	Fat score	Carcass length	Length of hind leg	Fat C	Fat B	Lumbar fat	Confor-mation
			Lean	SCF	Bone	Muscle	Fat	Bone									
Adjusted means (intercepts)																	
Sire line	4	2,9**	5,6***	5,1***	1,7	1,7	0,9	1,5	0,7	6,0***	1,1	8,4***	3,2**	1,1	1,3	2,7**	1,8
Dam line	1	1,4	5,8**	11,3***	0,2	0,4	0,2	0,2	0,5	1,9	5,5**	4,8**	3,8*	1,2	1,9	2,2	3,3*
Sire × dam	4	0,4	1,6	1,6	0,4	0,5	0,3	0,3	0,5	2,4*	0,4	0,5	0,9	1,6	2,0	2,8**	0,2
Regression																	
Common slope	1	525,4***	4,3	350,6***	76,5***	4,4	67,8***	73,2***	478,1***	86,6***	221,0***	591,8***	481,4***	147,6***	132,3***	153,4***	400,1***
Heterogeneity																	
Sire line	4	1,5	0,7	0,1	0,9	0,8	0,5	0,8	0,4	2,3*	0,9	1,9	1,2	1,2	0,6	0,8	1,3
Dam line	1	0,0	0,2	1,1	1,2	0,0	0,3	1,3	0,0	1,2	1,4	1,3	0,7	0,2	0,6	0,4	0,6

* $P < 0,10$; ** $P < 0,05$; *** $P < 0,01$.

Table 8(a) Least square means ± standard errors of sire and dam lines for carcass traits

Carcass trait	Sire lines					Dam lines		Pooled value
	DM	ME	IF	SAMM	FM	ME	FM	
Eye muscle area (cm^2)	12,5 ± 0,29^{ac}	11,9 ± 0,32^{a}	13,2 ± 0,26^{bc}	12,7 ± 0,25^{c}	12,2 ± 0,28^{a}	12,3 ± 0,17	12,6 ± 0,17	–
Chemical composition								
Muscle (%)	67,3 ± 0,81	65,6 ± 0,91	67,2 ± 0,75	68,4 ± 0,72	66,4 ± 0,77	66,8 ± 0,51	67,2 ± 0,49	67,0 ± 0,35
Fat (%)	15,7 ± 0,74	15,7 ± 0,84	15,5 ± 0,69	14,5 ± 0,66	16,3 ± 0,72	15,7 ± 0,47	15,4 ± 0,45	15,5 ± 0,32
Bone (%)	16,2 ± 0,52	18,6 ± 0,58	17,2 ± 0,48	17,1 ± 0,46	17,2 ± 0,49	17,5 ± 0,33	17,3 ± 0,32	17,4 ± 0,22
Dissected composition								
Lean (%)	78,4 ± 0,51^{a}	76,1 ± 0,58^{b}	78,9 ± 0,48^{a}	79,4 ± 0,46^{a}	78,3 ± 0,49^{a}	77,7 ± 0,32	78,8 ± 0,31	–
SCF (%)	4,59 ± 0,29^{ac}	5,19 ± 0,33^{a}	3,86 ± 0,27^{bc}	3,45 ± 0,26^{b}	4,38 ± 0,28^{a}	4,73 ± 0,18[1]	3,85 ± 0,18[2]	–
Bone (%)	16,9 ± 0,50	18,7 ± 0,57	17,2 ± 0,47	17,1 ± 0,45	17,4 ± 0,48	17,6 ± 0,32	17,4 ± 0,31	17,5 ± 0,22
Total carcass fat (kg)	2,34 ± 0,11	2,38 ± 0,12	2,42 ± 0,10	2,23 ± 0,10	2,47 ± 0,11	2,40 ± 0,07	2,33 ± 0,07	2,37 ± 0,05
KKCF (%)	3,81 ± 0,23^{a}	4,19 ± 0,27^{a}	3,01 ± 0,22^{b}	2,97 ± 0,21^{b}	4,01 ± 0,23^{a}	3,75 ± 0,15	3,45 ± 0,15	–
Fat C (mm)	4,23 ± 0,30	4,52 ± 0,34	3,98 ± 0,28	3,65 ± 0,27	4,09 ± 0,29	4,25 ± 0,19	3,94 ± 0,19	4,09 ± 0,13
Fat B (mm)	3,29 ± 0,26	3,81 ± 0,29	3,26 ± 0,24	3,00 ± 0,23	3,51 ± 0,25	3,54 ± 0,16	3,21 ± 0,16	3,37 ± 0,11

Table 8(a) *Continued*

Carcass trait	Sire lines					Dam lines		Pooled value
	DM	ME	IF	SAMM	FM	ME	FM	
Lumbar fat (mm)	4,72 ± 0,39^{ab}	5,76 ± 0,44^{a}	4,87 ± 0,37^{ab}	3,95 ± 0,35^{b}	5,06 ± 0,38^{a}	5,13 ± 0,25^{1}	4,61 ± 0,24^{2}	–
Fat score	2,49 ± 0,11	2,42 ± 0,13	2,42 ± 0,10	2,23 ± 0,10	2,52 ± 0,11	2,53 ± 0,07^{1}	2,29 ± 0,07^{2}	2,41 ± 0,05
Carcass lergth (cm)	58,0 ± 0,35^{a}	59,0 ± 0,40^{b}	57,0 ± 0,33^{c}	57,3 ± 0,32^{a}	59,3 ± 0,34^{b}	57,8 ± 0,22^{1}	58,4 ± 0,22^{2}	–
Length of hind leg (cm)	37,1 ± 0,23^{abc}	37,3 ± 0,26^{ac}	36,5 ± 0,22^{b}	36,9 ± 0,21^{ab}	37,6 ± 0,22^{c}	36,8 ± 0,14^{1}	37,3 ± 0,14^{2}	–
Conformation (kg/cm)	2,54 ± 0,01^{a}	2,51 ± 0,01^{ac}	2,59 ± 0,01^{b}	2,57 ± 0,01^{ab}	2,49 ± 0,01^{c}	2,56 ± 0,00^{1}	2,53 ± 0,00^{2}	–

Means with the same superscript in the same row do not differ significantly from each other.

Table 8(b) Least square means ± standard errors of regression coefficients of carcass traits of sire and dam lines, with cold carcass mass as independent variable

Carcass trait	Sire lines					Dam lines		Pooled value
	DM	ME	IF	SAMM	FM	ME	FM	
Regression coefficients								
Eye muscle area (cm^2)	0,588 ± 0,059	0,527 ± 0,071	0,592 ± 0,046	0,582 ± 0,048	0,728 ± 0,057	0,608 ± 0,037	0,599 ± 0,035	0,603 ± 0,026
Chemical composition								
Muscle (%)	−0,167 ± 0,167	0,006 ± 0,210	−0,321 ± 0,153	−0,272 ± 0,135	−0,021 ± 0,162	−0,137 ± 0,106	−0,173 ± 0,100	−0,155 ± 0,074
Fat (%)	0,463 ± 0,154	0,517 ± 0,186	0,743 ± 0,141	0,583 ± 0,125	0,498 ± 0,149	0,597 ± 0,097	0,525 ± 0,093	0,561 ± 0,068
Bone (%)	−0,296 ± 0,107	−0,523 ± 0,129	−0,422 ± 0,098	−0,311 ± 0,087	−0,477 ± 0,103	−0,460 ± 0,068	−0,352 ± 0,064	−0,406 ± 0,047
Dissected ccnposition								
Lean (%)	−0,164 ± 0,106	0,019 ± 0,128	−0,106 ± 0,097	−0,196 ± 0,086	−0,039 ± 0,103	−0,075 ± 0,067	−0,119 ± 0,064	−0,097 ± 0,047
SCF (%)	0,471 ± 0,061	0,510 ± 0,074	0,520 ± 0,056	0,504 ± 0,049	0,521 ± 0,059	0,535 ± 0,039	0,477 ± 0,037	0,506 ± 0,027
Bone (%)	−0,306 ± 0,105	−0,530 ± 0,127	−0,415 ± 0,097	−0,309 ± 0,086	−0,484 ± 0,102	−0,459 ± 0,067	−0,352 ± 0,064	−0,409 ± 0,064
Total carcass fat (kg)	0,216 ± 0,023	0,225 ± 0,028	0,250 ± 0,022	0,239 ± 0,019	0,218 ± 0,022	0,231 ± 0,015	0,228 ± 0,014	0,229 ± 0,011
KKCF (%)	0,098 ± 0,049^{a}	0,260 ± 0,059^{b}	0,198 ± 0,045^{c}	0,167 ± 0,040^{c}	0,289 ± 0,047^{b}	0,179 ± 0,031	0,226 ± 0,029	–
Fat C (mm)	0,376 ± 0,064	0,290 ± 0,077	0,363 ± 0,059	0,266 ± 0,052	0,428 ± 0,062	0,355 ± 0,041	0,354 ± 0,038	0,344 ± 0,028
Fat B (mm)	0,266 ± 0,054	0,263 ± 0,066	0,269 ± 0,049	0,239 ± 0,044	0,344 ± 0,052	0,294 ± 0,034	0,258 ± 0,033	0,276 ± 0,024
Lumbar fat (mm)	0,388 ± 0,082	0,371 ± 0,099	0,495 ± 0,075	0,392 ± 0,067	0,404 ± 0,079	0,472 ± 0,052	0,428 ± 0,049	0,450 ± 0,036
Fat score	0,157 ± 0,024	0,129 ± 0,029	0,183 ± 0,022	0,142 ± 0,019	0,176 ± 0,023	0,145 ± 0,015	0,169 ± 0,014	0,157 ± 0,011
Carcass length (cm)	1,119 ± 0,073^{a}	0,960 ± 0,088^{ab}	0,841 ± 0,067^{b}	0,926 ± 0,059^{ab}	0,989 ± 0,071^{ab}	1,002 ± 0,046	0,931 ± 0,044	–
Length of hind leg (cm)	0,555 ± 0,048	0,455 ± 0,058	0,447 ± 0,044	0,426 ± 0,039	0,444 ± 0,046	0,483 ± 0,030	0,448 ± 0,028	0,465 ± 0,021
Conformation (kg/cm)	0,124 ± 0,003	0,129 ± 0,004	0,137 ± 0,003	0,132 ± 0,003	0,132 ± 0,003	0,131 ± 0,002	0,130 ± 0,002	0,119 ± 0,006

Means with the same superscript in the same row do not differ significantly from each other.

fat vs. SCF) was very low, with a correlation of 0,42 between muscle and lean, and 0,17 between fat and SCF.

The IF sire line had the best eye muscle development of 13,2 cm^2, but did not differ significantly from the DM (12,5 cm^2) and SAMM (12,7 cm^2). The Merino had a significantly ($P<0,01$) smaller eye muscle area (11,9 cm^2) than the IF and SAMM, which did not differ significantly from the DM or FM (12,2 cm^2) sire lines. Although the DM, IF, SAMM and FM sire lines had significantly ($P<0,05$) more lean in the carcass than the Merino as indicated in Table 8, a very low correlation of 0,09 was found between eye muscle area and percentage lean in the carcass. This indicates that eye muscle area is not a good predictor of percentage lean in the carcass.

Total carcass fat, percentage fat, Fat C, and Fat B did not differ significantly between sire or between dam lines. However, large differences were found between some sire lines and between the dam lines for percentage SCF, KKCF and lumbar fat. The Merino sire had significantly ($P<0,05$) more SCF than the IF and SAMM sire lines, which was also found for the Merino dam line. The IF and SAMM had the least SCF of respectively 3,86 and 3,45% relative to cold carcass mass. This pattern was not reflected by the Fat C and Fat B measurements, where no significant differences were found between sire or between the dam lines. It was, however, partly reflected in the lumbar fat measurements of sire and dam lines, and the subjective fat score in dam lines. The Merino dam line had a significantly ($P<0,05$) higher subjective fat score and lumbar fat measurement than the FM dam line. Relatively high correlations were found between percentage SCF and Fat C (0,74), SCF and Fat B (0,71), and between SCF and lumbar fat (0,79), which indicate that lumbar fat is a better predictor of percentage SCF in the carcass than the other two measurements.

Significant sire × dam interactions ($P<0,05$) were found for KKCF and lumbar fat. A separate analysis was therefore carried out to calculate the least square means, regression coefficients and their respective standard errors of KKCF and lumbar fat against cold carcass mass for the individual crosses (Table 9).

The significant interaction for KKCF was caused by the fact that lambs born from the Merino dam had in all cases more KKCF than any of the other genotypes, except the FM × FM lambs born from FM ewes. As far as sire lines is concerned, the IF and SAMM had significantly less KKCF, which was brought about by their lower deposition rates as indicated by the significantly ($P<0,10$) lower regression coefficients of KKCF against cold carcass mass (Table 8b).

Sire lines differed significantly in respect of lumbar fat. The SAMM sire line had significantly ($P<0,05$) less lumbar fat than the Merino and FM lines. The significant ($P<0,05$) sire × dam line interaction for lumbar fat was brought about by lambs born from DM and Merino rams, crossed with FM ewes. They had more lumbar fat than the same lambs born from Merino ewes, while lambs born to IF, SAMM and FM sires out of FM ewes had less lumbar fat than their contemporaries born to Merino ewes.

The FM and Merino produced significantly ($P<0,01$) longer carcasses than the DM, IF, and SAMM sire lines, while the IF produced the shortest carcasses ($P<0,05$). Length of leg showed the same tendency with the FM having a significantly ($P<0,05$) longer hind leg than the other sire lines, followed by the Merino. The same significant ($P<0,05$) tendency was found between the dam lines. This resulted in significant differences in conformation between sire ($P<0,01$) and between dam ($P<0,05$) lines, with the FM sire line producing significantly less compact carcasses than the DM, IF, and SAMM sire lines. The FM sire line did not differ from the Merino sire line in this respect.

Table 9 Least square means (± *SE*) of KKCF (%) and lumbar fat thickness (mm) of the different genotypes

Genotype[1]	Carcass trait	LS Mean ± *SE*
DM × ME	KKCF	4,03 ± 0,31^{bc}
DM × FM	KKCF	3,59 ± 0,36^{bc}
ME × ME	KKCF	4,44 ± 0,38^{ac}
ME × FM	KKCF	3,93 ± 0,38^{bc}
IF × ME	KKCF	3,53 ± 0,34^{bc}
IF × FM	KKCF	2,50 ± 0,28^{b}
SAMM × ME	KKCF	3,10 ± 0,31^{b}
SAMM × FM	KKCF	2,84 ± 0,28^{b}
FM × ME	KKCF	3,62 ± 0,33^{bc}
FM × FM	KKCF	4,39 ± 0,31^{ac}
DM × ME	Lumbar fat	4,31 ± 0,52^{b}
DM × FM	Lumbar fat	5,14 ± 0,60^{ab}
ME × ME	Lumbar fat	5,42 ± 0,63^{ab}
ME × FM	Lumbar fat	6,09 ± 0,64^{a}
IF × ME	Lumbar fat	5,81 ± 0,56^{a}
IF × FM	Lumbar fat	3,93 ± 0,47^{b}
SAMM × ME	Lumbar fat	4,12 ± 0,52^{b}
SAMM × FM	Lumbar fat	3,79 ± 0,47^{b}
FM × ME	Lumbar fat	6,01 ± 0,55^{a}
FM × FM	Lumbar fat	4,11 ± 0,52^{b}

[1] Sire breed mentioned first.

$^{a-c}$ Means with the same superscript in the same column do not differ significantly from each other.

Discussion

Jackson (1968) as quoted by Casey (1982) stated that, as tissues grow differentially, the degree of maturity as indicated by the degree of fatness must be considered when any treatment response is assessed. This implies that breeds can only be legitimately compared at the same level of maturity. A shortcoming of this trial was that only carcasses were chemically analysed, and hence total body fat estimates were not available. Therefore total carcass fat content was used as an indicator of level of maturity. As different maturity types have different fat contents at the same weight (Casey *op. cit.*), the fact that the breeds used in this study did not differ significantly from each other in respect of total carcass fat at the same weight, implies that these breeds are to a large extent similar in degree of maturity and are therefore directly comparable. Casey (1982) found large differences between the SA Mutton Merino, Merino, Dorper and Pedi, slaughtered over a wide range of live masses. The Pedi had the most and the SA Mutton Merino the least amount of fat. Casey *op. cit.*,

however, did not indicate whether the difference in the amount of carcass fat between the Merino and SAMM breeds was significant.

The differences in age at slaughter of lambs born from the DM sires compared to those born from the other sire lines, confirmed the poor preweaning growth rates found by Greeff *et al.* (1989). This is contradictory to the results of Coetzee *et al.* (1971), who evaluated the SAMM, Merino, DM and Dormer breeds with regard to growth rate. They found that the Merino had a significantly lower growth rate than the other three breeds, and that the DM did not differ significantly from the SAMM. This suggests that the effects found in this study may have been caused by a ram effect.

The general lack of significant interaction effects between sire and dam breeds for important carcass traits, confirms the findings of Vesely *et al.* (1977) and Wolf *et al.* (1980). However, Croston *et al.* (1987) reported a significant sire breed × dam breed interaction for bone in the carcass and for lean:fat ratio. They found that the Ile de France crossed with the Scottish Blackface ewe had more bone in the carcass than when crossed with the Scottish Halfbred. Their results indicate that specific combining ability may be important in the design of breeding plans. However, from a commercial point of view, it would appear that this aspect may be of lesser importance than the fat distribution of the carcass. This suggests that selection of terminal sire breeds can be made on growth rate and carcass composition, especially for lean growth since present market requirements are for lean carcasses with minimum bone and optimum SCF.

The low dressing percentage of the Merino of 50,4% found in this study, confirms the results of Mare (1934) and Erasmus (1965) that the Merino has an inherently low dressing percentage. This is caused by a significantly ($P<0,05$) heavier skin and wool of the Merino, partly because of more wool, and its heavier head and trotters. This resulted in a lower warm carcass mass, compared to the other genotypes at the same live mass. This occurred in spite of the fact that the FM dam line had a heavier stomach and intestines than the Merino.

The carcass trait which showed the most variation between sire or between dam lines, was fat deposition at the different fat depots. Progeny of Merino and FM sires deposited more omentum fat and more KKCF than the IF, SAMM and DM. This resulted in the SAMM and IF having less intra-abdominal fat than the DM, FM or Merino. This also confirms the findings of McClelland & Russel (1972) who found that Finnsheep lambs deposited more fat intra-abdominally than the Scottish Landrace. Nitter (1974) also reported that lambs born from Finnsheep × Merino Landsheep dam lines were found to have more kidney fat than lambs born from six different Merino Landsheep F_1 crossbred dams. Similar results were recorded by Boylan *et al.* (1976), Dickerson (1977), Notter *et al.* (1983), and Fahmy (1985). However, this study indicates that lambs born from Merino ewes had in all cases, except in FM × FM lambs, a higher percentage KKCF than lambs born from the FM dam. The pure Merino had the most KKCF, with the FM × FM second. Therefore it would appear as if lambs with 25% and less Finn genes compare favourably to other genotypes in this regard.

Bruwer (1984) found that the optimum amount of fat in a carcass should be about 22%. This coincides with the point where the proportion of total amount of protein in the fat-free muscle is the highest; about 19,5%. After this no further increase in the proportion of protein in fat-free muscle will occur. As it is impractical to determine the amount of fat in each carcass, SCF is used as a predictor of total carcass fat.

According to Bruwer (1984) the optimum amount of SCF, when the carcass has 22% total fat, is about 8%. These guidelines were used in the Meat Grading Regulations (Marketing Act, 1968; Act 59 of 1968) to classify carcasses into different grades according to age of the animal at slaughter and the amount of SCF on the carcass. Table 10 shows the optimum carcass and slaughter masses for the different sire and dam lines, calculated from the parameters in Tables 3 & 8.

Table 10 Predicted optimum carcass and slaughter mass at 8% SCF

	Optimum carcass mass (kg) $\bar{X} \pm SE$	Slaughter mass (kg) $\bar{X} \pm SE$
Sire line		
DM	16,8 ± 0,155	40 ± 0,14
ME	16,5 ± 0,146	40 ± 0,13
IF	17,2 ± 0,166	40 ± 0,14
SAMM	17,4 ± 0,174	41 ± 0,14
FM	16,9 ± 0,158	40 ± 0,14
Dam line		
ME	16,7 ± 0,153	40 ± 0,13
FM	17,2 ± 0,167	41 ± 0,14
Mean	16,9	40

It is clear that the optimum carcass at 8% SCF, differs slightly between sire and between dam lines (Table 10). However, because of the differences in dressing percentage, the optimum slaughter mass is just about the same, i.e. 40 kg live mass for all genotypes. The estimated dressing percentage using fasted body mass, as understood by the producer, would then be *ca.* 42,5%.

This study indicated that lambs of all the different genotypes should be slaughtered at approximately 40 kg live mass. The FM dam line performed on average better than the Merino in respect of age at slaughter (earlier), dressing percentage (higher) and subcutaneous fat (less). From a study of the literature, Maijala (1984) concluded that infusion of less that 25% of Finn genes in a population, does not have a detrimental effect on the growth rate of lambs. In this study, however, the infusion of Finn genes improved growth rate of the lambs probably because the Merino is a specialized wool and not a mutton breed.

These advantages coupled to the high fertility of the FM (Greeff *et al.*, 1990; Hofmeyr, 1980), make this genotype a suitable dam line for intensive production systems. The SAMM and IF sire lines had higher dressing percentages and produced slightly leaner carcasses with less bone than the Merino sire line. As the SAMM and IF did not differ from each other in respect of important slaughter and carcass traits, either the SAMM or the IF can be used as a terminal sire

breed. However, the amount of wool and wool quality produced in systems where lambs are shorn before slaughter would be a major economic consideration in the selection of a sire and a dam breed. In this respect, Greeff & Hofmeyr (1988) indicated that lambs born to the SAMM produced a better quality wool than lambs born to the IF.

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