Lifetime meat production from six different F1 crossbred ewes

J.C. Greeff,* C.Z. Roux and G.A. Wyma
Animal and Dairy Science Research Institute, Private Bag X2, Irene 1675, Republic of South Africa

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The efficiency of meat production with regard to kilogram of lamb weaned per kilogram metabolic mass of ewes at mating of six different F1 crossbred populations, viz. Finnish Landrace × Merino (FL × M), Border Leicester × Merino (BL × M), Bleu de Maine × Merino (BdM × M), Texel × Merino (T × M), Cheviot × Merino (C × M) and Merino Landsheep × Merino (ML × M), with their flock structures in equilibrium, were evaluated with each other over their lifetime. The FL × M was the most efficient cross followed by the T × M, BL × M, C × M, BdM × M and ML × M. Results indicate that size and other individual components of productivity are not reliable indicators of total production or efficiency of production.

Die doeltreffendheid van vleisproduksie ten opsigte van kilogram lam gespeen per kilogram metaboliese massa van ooie by paring, van ses verskillende F1-kruispopulasies, nl. Finse Landras × Merino (FL × M), Border Leicester × Merino (BL × M), Bleu de Maine × Merino (BdM × M), Texel × Merino (T × M), Cheviot × Merino (C × M) en Merino Landskaap × Merino (ML × M), met hul kuddestrukture in ekwilibrium, is oor hul leeftyd met mekaar vergelyk. Die FL × M was die doeltreffendste kruising gevolg deur die T × M, BL × M, C × M, BdM × M en ML × M. Die resultate dui aan dat grootte en individuele komponente van produktiwiteit nie 'n getroue weergawe van totale produksie of doeltreffendheid van produksie is nie.

Keywords: Crossbreeding, growth, reproduction, sheep, survival, total production.

* To whom correspondence should be addressed.

Introduction

Low productivity is a major problem in the sheep industry of the Republic of South Africa. Methods to increase ewe productivity by genetical means vary from crossbreeding to selection. A measure of the productivity of an ewe is the total mass of lambs marketed plus her wool production over her lifetime. Thus, lifetime production involves all the components of fitness, i.e. longevity, the number of lambs born, mortality rate and growth, together with wool production.

With the current relatively high prices of mutton and lamb in South Africa, a shift in production systems from extensive to more intensive conditions is taking place, especially in the high rainfall areas and in areas where water is available for irrigation purposes. Under such conditions, lamb and mutton should be produced mainly from crossbred ewes because of the advantage of heterosis and breed specialization. Such lamb production systems are common in Ireland (More O'Ferrall & Timon, 1977), United Kingdom (Wolf, Smith & Sales, 1980) and in Australia (McGuirk, Bourke & Manwaring, 1978). In South Africa, the Merino is sometimes crossed with mutton breeds to produce slaughter lambs. A more profitable system, based on overseas evidence, may be implemented in suitable areas where first cross ewes may be used to produce lambs on irrigated pastures from terminal sire breeds to fully utilize the effects of heterosis and complementarity.

This study reports on the performance of six different crossbreeds in the production of meat, using the Merino (M) as foundation stock crossed with various white woolled sire breeds, as well as the most profitable flock structure for each cross. Wool production was not studied. Preliminary results were discussed by Hofmeyr (1982).

Material and Methods

Six different white woolled sire breeds, viz. Finnish Landrace (FL), Border Leicester (BL), Bleu de Maine (BdM), Texel (T), Cheviot (C) and Merino Landsheep (ML), were selected on the average performance of each breed in their country of origin, with regard to fertility (Finnish Landrace and Bleu de Maine), milk production (Bleu de Maine), growth rate (Border Leicester, Cheviot and Merino Landsheep), lean growth and conformation (Texel). Five Finnish Landrace, 4 Border Leicester, 4 Bleu de Maine, 6 Texel, 4 Cheviot and 5 Merino Landsheep rams were used. Each sire breed was crossed with approximately 100 Merino ewes from the same base population. The F1 ewes, born during 1970, 1971 and 1972, were each crossed with the same sire breeds during their lifetime from 1972 until 1978. A minimum of six rams were used per sire breed. Hofmeyr (1982) should be consulted for details. The number of lambs born per ewe breed is indicated in Table 2. Very few Merino ewes were produced during 1970 to 1972 as Merino ewes were bought in. Those produced, were sold when most of them were about four years old. Only five Merino ewes in the five-year-old group were available. Death rates of the Merino could thus not be determined, and the equilibrium age structure of the Merino could not be calculated. The available production statistics for the Merino ewes are presented.

Statistical analysis

Total productivity or efficiency of any production system is determined by the input–output ratio. In a lamb production system the main input cost item is the amount of feed required by the breeding ewes. Woolliams & Weiner

(1983) found no significant differences in feed conversion efficiency among lambs of five crossbred genotypes. Body mass of the ewe flock can be used to estimate feed intake as maintenance requirements of the breeding ewes can be assumed proportional to metabolic live mass or body mass^{0,75} (McDonald, Edwards & Greenhalgh, 1973). Thus, a measurement of efficiency, in terms of meat production, is the ratio: kilogram lamb weaned per kilogram ewe mated^{0,75}. This approach was also used by Mann, Smith, King, Nicholson & Sales (1984). The ratio includes mass of the ewes at mating as an indication of maintenance requirements, conception rates, fecundity, survival rate as well as the survival rate and growth rate of their lambs. This approach, however, ignores any extra feed associated with higher productivity especially with regard to ewes with bigger litter sizes. Such ewes have higher food requirements which might overestimate true differences between genotypes (Hohenboken, 1986).

Different crossbred populations can probably best be compared by calculating their productivity under a given production system. Assume that a production unit comprises 100 ewes, and that, as crossbred ewes die or become infertile, they are replaced by young ewes specially bred for the purpose. Culling and survival rates will then induce an equilibrium age structure in the flock after some time has elapsed.

The following mathematical scheme, derived from Karlin (1968) was used to calculate the equilibrium age structure for each genotype.

Let n_0^{t-1} = number of ewes kept for replacement purposes
n_1^{t-1} = number of ewes available for their first mating in year t
n_2^{t-1} = number of ewes available for their second mating in year t
n_q^{t-1} = number of ewes available for their q-th mating in year t

Let Q = proportion of breeding animals that survive or are kept
Q_0 = proportion of animals that survive between weaning and 1st mating (normally = 1)
Q_1 = proportion of animals that survive between the 1st and 2nd mating
$(1 - Q_i)$ = death rate of the animals

Then, the number of animals brought into the population for the first time, i.e. the number of replacement ewes

$$n_0^t = (1 - Q_0)n_0^{t-1} + (1 - Q_1)n_1^{t-1} + (1 - Q_2)n_2^{t-1} + (1 - Q_q)n_q^{t-1}$$

and

$$n_1^t = Q_0 n_0^{t-1}$$
$$n_2^t = Q_1^{t-1}$$

where n = number of animals present for mating in year t.

The proportion of ewes (p_i^t) mated:

for the first time

$$p_1^t = \frac{n_1^t}{\Sigma n} = \frac{Q_0}{Q_0 + Q_0Q_1 + Q_0Q_1Q_2 + \dots + (Q_0Q_1 \dots Q_q)}$$

for the second time

$$p_2^t = \frac{n_2^t}{\Sigma n} = \frac{Q_1Q_0}{Q_0 + Q_0Q_1 + Q_0Q_1Q_2 + \dots + (Q_0Q_1 \dots Q_q)}$$

for the third time

$$p_3^t = \frac{n_3^t}{\Sigma n} = \frac{Q_2Q_1Q_0}{Q_0 + Q_0Q_1 + Q_0Q_1Q_2 + \dots + (Q_0Q_1 \dots Q_q)},$$

etc.

Weaning weight was analysed with the general procedure of Harvey (1977). The model used was:

$$Y_{ijkmn} = \mu + a_i + b_j + c_k + d_m + e_{ijkmn}$$

where

Y_{ijkmn} = observation on one lamb
μ = mean
a_i = effect of the i-th sire breed
b_j = effect of the j-th ewe breed
c_k = effect of age of the ewe
d_m = effect of sex
e_{ijkmn} = random error, normally distributed with mean zero and variance σ^2.

The effect of age of the ewe was confounded with the year of measurement effect. All effects were considered fixed.

Management

Standard sheep management practices were followed and ewes were kept on a pelleted diet during mating, late pregnancy and lactation. After weaning, ewes were kept on *Eragrostis curvula* pastures until mating. Ewes were teased with vasectomized rams. Handmating was practised and took place during April and May each year. Ewes were mated for the first time at about 18 months of age and lambed during September and October. All lambs were weighed and tagged within one day after birth. Survival rates of lambs and ewes were recorded. Ewes were not culled on account of poor performance but those that died unnaturally were excluded from this study. An insignificant number of ewes were culled in this way.

Results and Discussion

Survival rate of ewes

Table 1 indicates the number of ewes mated for the first time and the proportion of ewes (Q_i) surviving from one mating to the next until the eighth mating.

Ewes of the ML × M cross generally had the highest survival rates followed closely by T × M and BdM × M, especially at young ages. Ewes of the FL × M cross had the lowest survival rates, which may be ascribed to high fertility.

Table 1 Proportion of ewes (p_i^s) surviving from one mating to the next

Breed/ Cross	Number of ewes	Mating							
		1	2	3	4	5	6	7	8
Merino	96	1,0	–	–	–	–	–	–	–
FL × M	114	1,0	1,0	0,91	0,89	0,72	0,76	0,57	0,45
BL × M	107	1,0	1,0	0,94	0,97	0,76	0,80	0,78	0,70
BdM × M	89	1,0	1,0	0,96	0,92	0,85	0,85	0,77	0,49
T × M	109	1,0	1,0	0,99	0,93	0,90	0,87	0,71	0,53
C × M	90	1,0	1,0	0,98	0,91	0,76	0,75	0,74	0,50
ML × M	121	1,0	1,0	0,98	0,98	0,86	0,81	0,89	0,60

Mass of ewes at mating

Average mass of ewes at mating according to ewe breed and age is shown in Figure 1 .

Ewe mass increased until five years of age. The sudden increase in mass at the eighth year in most ewe breeds should be viewed with caution, because of the small number of ewes involved at this stage, and may be related to a year-effect. The ML × M ewes were on average 8—12% heavier than the other genotypes until the third mating, whereafter the BL × M ewes became the heaviest until seven years of age. The T × M and C × M ewes were smaller than the other crossbreds for a large part of their lives, whereas the Merino were on average 14—21% lighter than the mean of all the genotypes during their first five years.

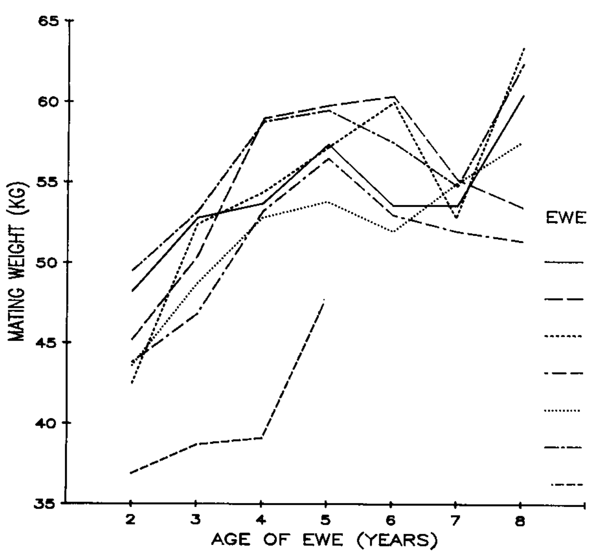

Figure 1 Average weight of ewes at mating according to ewe breed and age.

Fertility

Average levels of fertility (number of ewes lambed per ewes mated) and fecundity (number of lambs born per ewe lambed) are indicated in Figures 2 and 3, respectively, for the different ewe breeds.

Except for the Merino, T × M and BL × M, a general increase in fertility took place from the first to the second lambing at about three years of age, whereafter it tended to decline. The large variation at the seventh lambing is due to the small number of ewes surviving to eight years of age. The Merino had a noticeable lower fertility of 2—10% less than the average for all ewe breeds for the first three lambings. The low fertility of the Merino at five years of age should be viewed with caution because of the small number of ewes involved.

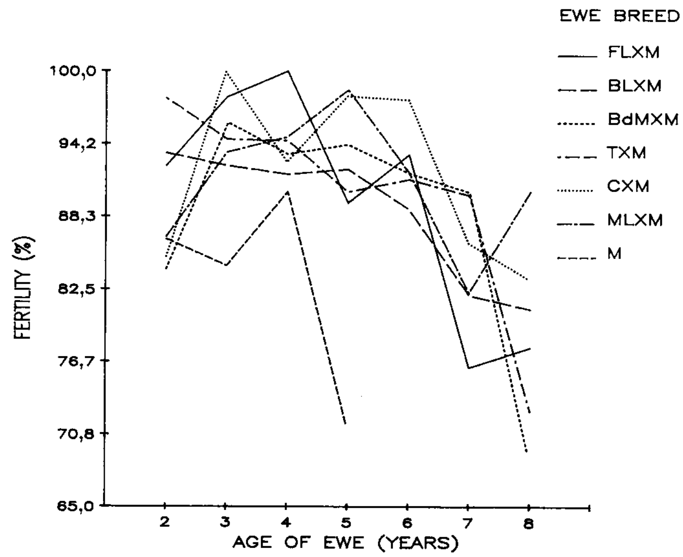

Figure 2 Fertility according to ewe breed at different ages.

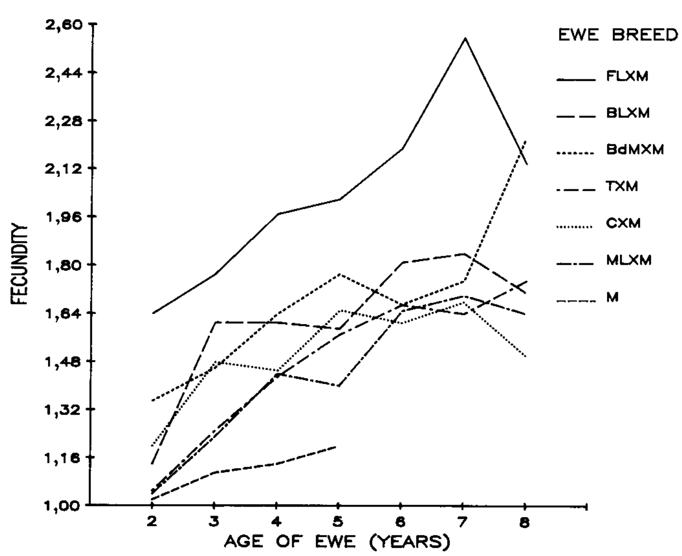

Figure 3 Fecundity according to ewe breed at different ages.

From 3—7 years of age, fertility of the BL × M ewes was about 3% below average, whereas fertility of the other ewe breeds oscillated more closely around the mean.

Figure 3 confirms the general trend of an increase in fecundity with age increase until the sixth lambing, whereafter it declined. Fecundity of the FL × M ewes was on average 17—38% higher than that of the other ewe breeds, confirming the results of Maijala (1984), while fecundity of the Merino was 15—22% below average. Up to the sixth lambing, at seven years of age, fecundity of the T × M and ML × M ewes was lower than that of the BL × M and BdM × M ewes. Fecundity of the other ewe breeds oscillated more closely around the mean.

Survival rate of lambs

Survival rates at birth (ratio of live lambs to total lambs born) for the different breeds are indicated in Figure 4. Except for lambs of the BdM × M and ML × M ewes, survival rate increased until the second lambing, at three years of age, whereafter it declined. Lambs of the BL × M and T × M ewes had a higher (1—7%) survival rate until seven years of age, than the average for all groups, while the survival rates of the BdM × M, C × M and ML × M lambs oscillated more closely around the mean. Despite the high fecundity of the FL × M ewes, their lambs for the first and second lambing had a better than average survival rate of 1 and 2% respectively.

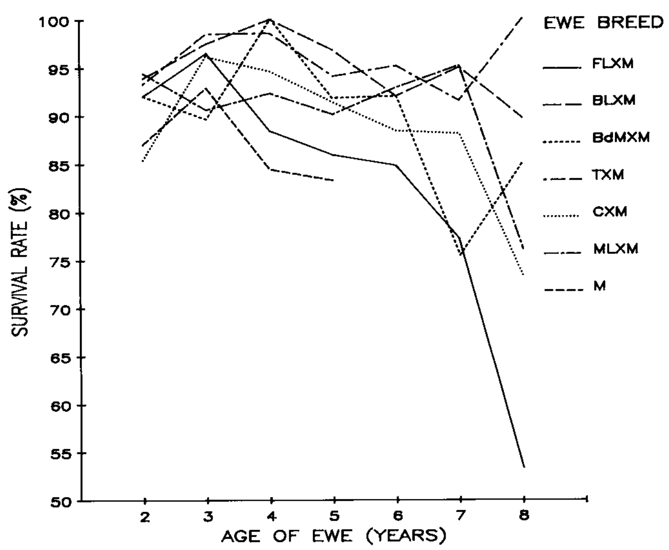

Figure 4 Survival rate of lambs at birth according to ewe breed at different ages.

Survival rate decreased only from the third lambing (four years of age) onwards. A drastic decline occurred at seven and eight years of age, especially for lambs born from the FL × M ewes. Survival rates of lambs from FL × M ewes were, however, still better than those of the Merino during the first four lambings.

Except for the C × M, survival rate from birth to weaning (Figure 5) increased up to four years of age,

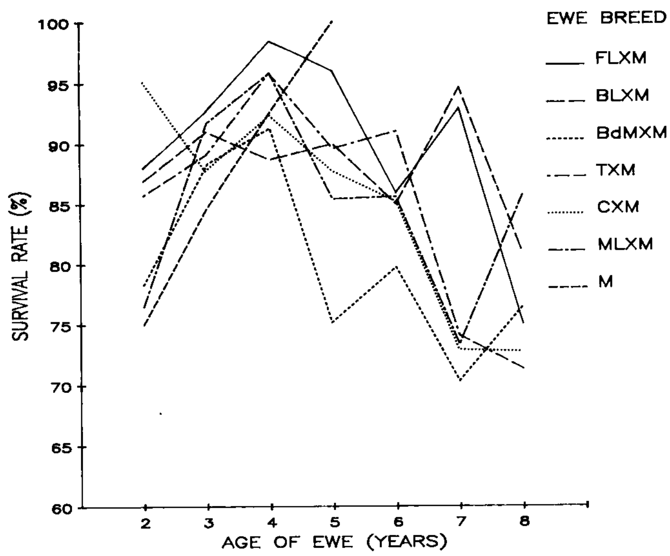

Figure 5 Survival rate of lambs from birth to weaning per ewe breed at different ages.

whereafter a decline was noticed. The erratic pattern of survival from birth to weaning at eight years of age must, as mentioned previously, be viewed with caution owing to the small numbers of lambs involved. The same applies for the 100% survival rate for the Merino, as only five lambs were born in this age group (5 years). Survival rates from birth to weaning of lambs from BdM × M ewes were always below the mean for all genotypes in all age groups. At the fourth, fifth and six lambing, lambs of the BdM × M ewes had the lowest survival rate, whereas lambs of the Merino ewes had the lowest survival rate at the first and second lambings. Despite the high fecundity of the FL × M ewes, their lambs had on average the highest survival rate from birth to weaning, followed by the BL × M lambs.

Weaning weight

Least-square means of the corrected weaning weight of individual lambs at 100 days of age are given in Table 2. A significant interaction ($P < 0{,}05$) was found between ewe breed and age. No significant differences were found between lambs of the BL × M, BdM × M, T × M, and ML × M ewes, but lambs of the Merino, FL × M and C × M ewes had significantly ($P < 0{,}01$) lower weaning weights.

Efficiency of lamb production

Efficiency of lamb production, expressed as kilogram of lamb weaned at 100 days of age per kilogram of ewe mated^{0,75}, is shown in Figure 6. The FL × M ewes performed the best over the first five lambings, confirming the results of Ercanbrack & Knight (1985). This indicates the high productivity of Finnish Landrace crosses compared with other breeds. A striking feature is the low efficiency of the Merino and ML × M ewes. Only from the fifth lambing, at six years of age, did the ML × M ewes performed better than any of the other genotypes. The BL × M, BdM × M, T × M and C × M

Table 2 Least-square means (± *SE*) of weaning weight of lambs at 100 days of age according to ewe type at different ages

Age of ewe (years)	Ewe breed													
	n[a]	Merino	n	FL × M	n	BL × M	n	BdM × M	n	T × M	n	C × M	n	ML × M
2	31	26,2 ± 1,13	84	25,9 ± 0,85	57	29,4 ± 0,93	36	29,4 ± 0,44	38	28,9 ± 1,06	40	26,8 ± 1,05	47	29,4 ± 0,96
3	32	28,9 ± 1,00	74	26,7 ± 0,88	68	30,1 ± 0,87	49	31,0 ± 0,98	58	29,0 ± 0,95	62	27,7 ± 0,92	40	30,9 ± 1,04
4	41	27,1 ± 1,24	90	26,7 ± 0,73	54	30,0 ± 0,85	53	29,9 ± 0,86	77	31,9 ± 0,75	58	29,4 ± 0,83	74	29,2 ± 0,78
5	8	23,4 ± 1,74	78	27,6 ± 0,73	77	30,9 ± 0,78	65	30,6 ± 0,82	90	29,5 ± 0,71	67	26,9 ± 0,81	78	31,1 ± 0,72
6		–	67	27,6 ± 0,80	68	31,6 ± 0,79	55	29,7 ± 0,85	91	29,2 ± 0,73	52	27,5 ± 0,87	88	29,7 ± 0,73
7		–	21	27,4 ± 1,28	53	31,9 ± 0,91	26	34,0 ± 1,44	43	29,2 ± 1,05	26	27,2 ± 1,41	54	29,6 ± 0,93
8		–	6	28,4 ± 3,80	21	29,6 ± 1,76	13	29,6 ± 1,85	10	29,0 ± 1,96	8	23,8 ± 2,43	18	31,1 ± 1,62

[a] Number of lambs per group.

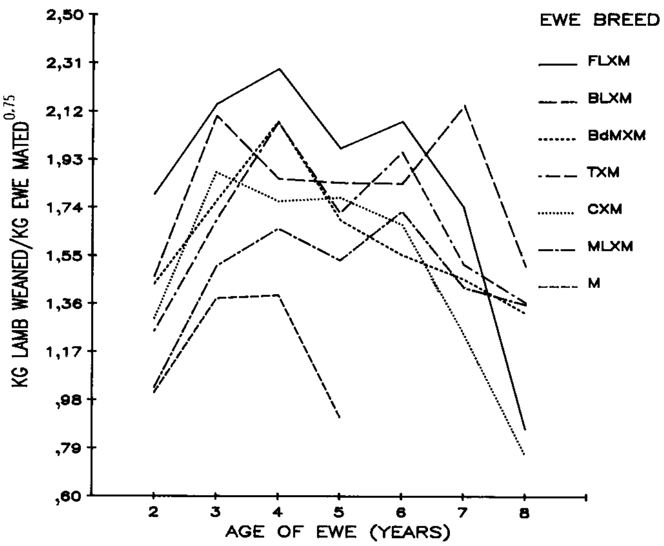

Figure 6 Total productivity (kg lamb weaned/kg ewe mated$^{0.75}$) according to ewe breed at different ages.

ewes performed close to the mean, of which the BL × M ewes performed the best during the first two lambings. From the third lambing, the performance of these four genotypes oscillated closely around the mean.

Total productivity

In view of the differences in efficiency of lamb production between genotypes, the following questions arise: (i) Which cross is the most productive and (ii) what will the optimum age structure for each cross be? The assumption is made that there is a constant supply of ewes of each cross available for replacements purposes. Assume that there is a flock of 100 ewes per cross. Then, with one age group, the flock will consist of 100 young ewes available for mating for the first time. With two age groups, approximately 50 ewes will be culled and replaced each year, and with three age groups, approximately one third of the ewes will be culled and replaced annually, etc. The total productivity of each cross for a flock of 100 ewes can be calculated for a different number of age groups per cross when the groups are in equilibrium.

Survival rate of ewes was used to calculate the equilibrium age structure of each cross. The proportion of ewes of each cross when age structure is in equilibrium (until the seventh mating) is indicated in Table 3.

Total productivity (kg lamb weaned/kg ewe mated$^{0.75}$) of all crosses with different numbers of age groups (at lambing) and age structures in equilibrium, are indicated in Figure 7. It is clear that, according to this definition of total productivity, the optimum production of each cross under an equilibrium flock structure differs with different numbers of age groups. Except for the BdM × M and the BL × M, all the other crosses had the highest performance with five age groups under an equilibrium age structure.

The FL × M had the highest productivity (viz. 17% higher than the mean of all groups) owing to their exceptionally higher fecundity, and the higher mean survival rate of their lambs from birth to weaning, which was 25% and 5% better, respectively, than the mean for all groups. The low weaning weight of their lambs, which was 8% lower than the mean for all groups, decreased their overall performance to the present level.

Total productivity of the BL × M was 7% better than

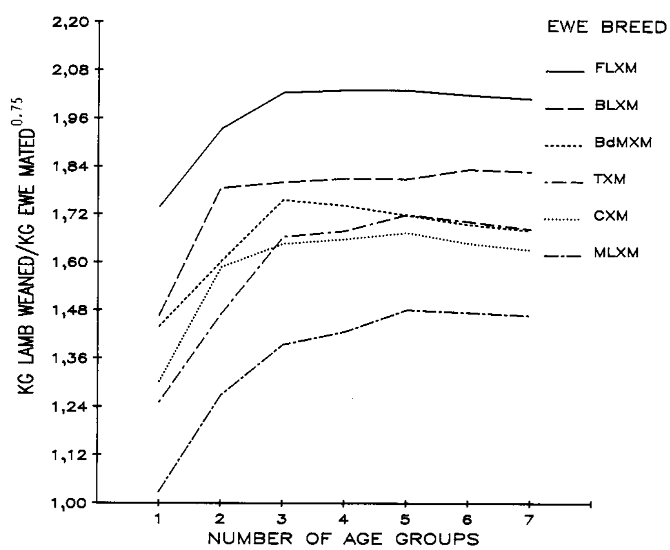

Figure 7 Total productivity (kg lamb weaned/kg ewe mated$^{0.75}$) according to ewe breed with different numbers of age groups.

Table 3 Proportion of ewes ($p_i^{\dagger}$) of each cross when age structure is in equilibrium

Number of age groups	Age group (years)	Cross FL × M	BL × M	BdM × M	T × M	C × M	ML × M
1	2	1,00	1,00	1,00	1,00	1,00	1,00
2	2	0,50	0,50	0,50	0,50	0,50	0,50
	3	0,50	0,50	0,50	0,50	0,50	0,50
3	2	0,35	0,35	0,34	0,34	0,34	0,34
	3	0,34	0,33	0,34	0,34	0,34	0,33
	4	0,31	0,32	0,32	0,32	0,32	0,33
4	2	0,28	0,27	0,26	0,26	0,26	0,26
	3	0,27	0,26	0,26	0,26	0,25	0,25
	4	0,25	0,24	0,25	0,25	0,25	0,25
	5	0,20	0,23	0,23	0,23	0,23	0,24
5	2	0,25	0,24	0,23	0,22	0,23	0,21
	3	0,24	0,22	0,23	0,22	0,23	0,21
	4	0,22	0,21	0,22	0,21	0,22	0,21
	5	0,18	0,20	0,19	0,20	0,19	0,20
	6	0,11	0,13	0,13	0,15	0,13	0,17
6	2	0,24	0,22	0,21	0,20	0,22	0,19
	3	0,23	0,21	0,21	0,20	0,22	0,19
	4	0,21	0,20	0,20	0,19	0,20	0,19
	5	0,17	0,19	0,18	0,18	0,18	0,18
	6	0,10	0,12	0,12	0,14	0,12	0,15
	7	0,05	0,06	0,08	0,09	0,06	0,10
7	2	0,23	0,21	0,20	0,19	0,21	0,18
	3	0,23	0,20	0,20	0,19	0,21	0,18
	4	0,21	0,19	0,19	0,18	0,20	0,18
	5	0,17	0,18	0,17	0,17	0,18	0,17
	6	0,10	0,12	0,12	0,13	0,12	0,14
	7	0,05	0,07	0,08	0,09	0,06	0,09
	8	0,01	0,03	0,04	0,05	0,02	0,06

the mean for all groups, mainly because ewe weight, fertility and fecundity was close to the mean, whereas survival rate of their lambs at birth was 4% higher, survival rate from birth to weaning 2% higher, and weaning weight of their lambs 4% higher than the mean of all groups.

The BdM × M and T × M had a similar level of performance with five or more age groups under an equilibrium age structure, which was close to the mean for all genotypes – despite large differences between these two genotypes regarding the components of total productivity. Mature weight of the BdM × M at mating was 6% more than that of the T × M, while fertility of both groups was close to the mean. Fecundity of the T × M was about 13% lower than that of the BdM × M, but was cancelled by the higher survival rate at birth (6%) and higher survival rate from birth to weaning (7%) of lambs born to the T × M when compared to those of the BdM × M.

The overall performance of the C × M was 5% below the mean for all genotypes, mainly by virtue of their lower fecundity (5%), lower weaning weight (5%) and the lower survival rate of their lambs at birth (2%) relative to the mean for all genotypes. These deficiencies more than offset any advantage from the small mature body size of the breeding ewes.

The ML × M had the lowest productivity of 15% below the mean for all groups. The higher weaning weight of their lambs was completely eroded by their higher ewe weight (4%) and lower fecundity (13%), relative to the mean. This result emphasizes the fact that ewe size is not a reliable measure of productivity.

Conclusion

The FL × M was the most, and the Merino the least productive type in the present study with regard to total productivity. This confirms the findings of Cochran, Notter & McClaugherty (1984) and Dickerson (1977). However, Taylor, Moore, Thiessen & Bailey (1985) suggested that sheep have a high maternal maintenance requirement between lambings compared to cattle. They concluded that, for intensive conditions, this serious disadvantage will not be overcome unless sheep attain at least their average expectation of first lambing at less than one year of age and at 200-day intervals thereafter. In this regard, the FL × M will further outperform the other crosses owing to the additional advantage of their well known early sexual maturity (Maijala, 1984). However, this genotype will require improved husbandry systems to take full advantage of its potential.

The large differences in productivity between crosses were brought about by several factors of which fecundity, survival rate and live weight of the ewe at mating were the most important. The low productivity value for the ML × M was unexpected. If different genotypes are to be evaluated, it should therefore be done in terms of an input–output ratio where statistics of the whole production cycle are used. If the production cycle is fragmented into different parts and statistics of these parts are evaluated separately, care should be taken not to draw conclusions with regard to differences in total productivity between genotypes.

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