Genetic parameters for reproduction rate in the Tygerhoek Merino flock. 2.Genetic correlations with wool and live mass traits

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Data of the Tygerhoek Merino flock were used to obtain estimates of genetic correlations of 18 months wool and pre-mating live mass traits with average reproduction over two to five lambing opportunities, as well as between pre-mating live mass and subsequent reproduction in age groups of 2 - 6 years by paternal halfsib procedures. The wool traits considered were clean fleece mass (CFW), greasy fleece mass (GFW) and fibre diameter (FD). Reproduction traits were lambs born/ewe conceived (Lb/Ec), lambs born/ewe mated (Lb/Em), and lambs weaned/ewe mated (Lw/Em). The genetic correlations of 18 months wool traits with reproduction traits were not very accurate and estimates larger than twice their standard errors were obtained only on a few occasions. The genetic correlation between CFW and Lb/Ec tended to be positive. There was, however, evidence of a negative genetic correlation between CFW and the composite trait of Lw/Em both in literature cited and in the present investigation. The genetic correlations of 18 months FD with reproduction traits were variable. The genetic correlation of live mass with reproduction traits was positive, both within age groups and when 18 months pre-mating live mass was correlated with average reproduction over a number of lambing opportunities. Several estimates involving Lb/Ec, Lb/Em, and Lw/Em were larger than twice their obtained standard errors. The obtained genetic correlations were in correspondence with literature cited. It was concluded that selection for live mass is unlikely to cause negative correlated responses in reproduction, unless live mass at a very young age is used as a selection criterion.

Data van die Tygerhoek-Merinokudde is gebruik om beramings van genetiese korrelasies van 18-maande-wol- en liggaamsmassa-eienskappe met gemiddelde reproduksie oor twee tot vyf lamgeleenthede en van paarmassa met daaropvolgende reproduksie binne ouderdomsgroepe volgens halfsibmetodes te bereken. Die woleienskappe wat ondersoek is, was skoonvagmassa (CFW), rouvagmassa en veseldikte (FD). Reproduksie-eienskappe was lammers gebore/ooi beset (Lb/Ec), lammers gebore/ooi gepaar (Lb/Em) en lammers gespeen/ooi gepaar (Lw/Em). Die genetiese korrelasies van 18-maande-woleienskappe met reproduksie was nie baie akkuraat nie en beramings groter as twee maal hul standaardfoute is slegs by 'n paar geleenthede verkry. Die genetiese korrelasie tussen CFW en Lb/Ec was oorwegend positief. Daarteenoor was daar aanduidings van 'n negatiewe genetiese korrelasie tussen CFW en die saamgestelde eienskap Lw/Em, beide in aangehaalde literatuur en in die huidige ondersoek. Die genetiese korrelasie van FD met reproduksie was veranderlik. Die genetiese korrelasie van liggaamsmassa met reproduksie-eienskappe was positief, beide binne ooi-ouderdomsgroepe en tussen 18-maande-paarmassa en gemiddelde reproduksie oor 'n aantal lamgeleenthede. Etlike beramings op Lb/Ec, Lb/Em en Lw/Em was meer as twee maal groter as hulle verkreë standaardfoute. Die beraamde genetiese korrelasies was in ooreenstemming met aangehaalde literatuur. Dit is onwaarskynlik dat seleksie vir liggaamsmassa nadelige gekorreleerde reaksies in reproduksie sal veroorsaak, tensy liggaamsmassa op 'n baie jong ouderdom as seleksiekriterium gebruik word.

Keywords: Genetic correlations, reproduction, wool traits, live mass, Merino sheep

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Introduction

In the first paper of this series, attention was given to heritability estimates for reproduction rate in the Tygerhoek Merino flock (Cloete & Heydenrych, 1987). Production traits in sheep are, however, not always unrelated (Turner & Young, 1969). A proper knowledge of genetic interrelationships between production traits is therefore a prerequisite for the formulation of efficient breeding plans. Wool production and live mass can be considered the most important production traits in woolled sheep, apart from reproduction.

Results reviewed by Turner (1972), indicated no clear genetic relationship between reproduction and wool yield. Kennedy (1967) reported a negative genetic correlation between these characteristics, whilst Clarke (1972) obtained a small negative correlated response in lamb and hogget wool production following selection for increased reproductive performance. Results presented by Barlow (1974) and those obtained by Cloete & Heydenrych (1986), on the other hand, suggest a higher twinning rate in ewes selected on clean fleece mass. This result could, however, not be confirmed by time trends in both these investigations. It thus appears that the genetic association between wool characteristics and reproduction in ewes has not been finalized.

Previous results indicated a positive phenotypic relationship of live mass with reproduction (Cloete &

Heydenrych, 1986), whereas the genetic relationship between these characteristics also tended to be positive (Turner, 1972). Other results in the literature, however, suggest the possibility of a negative genetic relationship between live mass and reproduction (Scholtz & Roux, 1984; Roux & Scholtz, 1984; Lasslo, Bradford, Torell & Kennedy, 1985). Selection for reproduction rate resulted in a small positive correlated response in live mass at 14 - 16 months in New Zealand Romney sheep (Clarke, 1972), but not in Irish Galway sheep (Hanrahan, 1976). From these results it appears that, although the general tendency favours a positive genetic correlation between live mass and reproduction, there still is some uncertainty with regard to this aspect.

The present data were therefore used to obtain estimates of the genetic correlations between fleece characteristics and live mass at an early age (18 months) and average reproduction over a number of lambing opportunities in ewes. Genetic correlations between live mass and subsequent reproduction within age groups were simultaneously investigated.

Material and Methods

The data included in the present investigation were part of the data discussed by Cloete & Heydenrych (1987). Genetic parameters were obtained by halfsib analysis of variance procedures (Turner & Young, 1969) using the LSML76 computer program (Harvey, 1977) to calculate variance and covariance components for the estimation of genetic correlations by mixed-model methods in an unbalanced experiment (Harvey, 1970). The statistical analyses were similar to that reported earlier (Cloete & Heydenrych, 1987) and involved the use of Model 03 (Harvey, 1977; 1982) with sires treated as a random variable nested within contemporary groups. Two sets of data were considered once more, the first one including progeny of selection group rams used in two mating seasons, and the second one including progeny of all the available selection and control group rams, as was reported earlier. Covariance components for the calculation of genetic correlations between pre-mating live mass and subsequent reproduction at ages of 2 - 6 years, and between pre-mating live mass at 1,5 years and reproduction averaged over two, three, four or five lambing opportunities, were obtained from the same analyses used to determine the heritability estimates as reported earlier. Table 1 of the previous publication (Cloete & Heydenrych, 1987) must be consulted for the number of observations (n), degrees of freedom for sires within contemporary groups ($df_{s/cg}$) and for error (df_e), and relevant k values for these estimates. Data regarding wool traits were incomplete for all the progeny born in 1982 and for a few individuals born earlier. These progeny were thus excluded for the determination of genetic correlations of 18 months wool traits with average reproduction over two, three, four or five lambing opportunities. Relevant values of n, $df_{s/cg}$, df_e and k for these analyses are presented in Table 1. The wool traits considered were greasy fleece mass, clean fleece mass and fibre diameter at 18 months of age. The reproduction traits included were ewes conceived/ewe mated (Ec/Em), lambs born/ewe conceived (Lb/Ec), lambs born/ewe mated (Lb/Em), pre-weaning mortalities/lamb born (Ld/Lb) and lambs weaned/ewe mated (Lw/Em). All the available records were used to estimate genetic correlations involving Ec/Em, Lb/Em and Lw/Em, whilst only ewes conceiving at least once were considered in the analyses on average Lb/Ec and Ld/Lb over a number of lambing opportunities. Barren ewes were similarly excluded in the within age group analyses on Lb/Ec, in which Ld/Lb were excluded as a dependent variable. Genetic correlations between wool and live mass traits and reproduction were calculated according to the standard formula (Harvey, 1977). Standard errors for the genetic correlations were calculated by the modified formula given by Tallis (1959).

Table 1 The number of observations (n), degrees of freedom for sires/contemporary groups ($df_{s/cg}$) and error (df_e) and k values for the analyses on ewes available for two to five lambing opportunities in the first and second sets of data

	Number of lambing opportunities			
Item	2	3	4	5
First set of data				
per ewe mated				
n	662	555	435	362
$df_{s/cg}$	38	38	35	35
df_e	600	492	377	304
k	10,5	8,8	7,5	6,3
per ewe conceived				
n	629	544	430	358
$df_{s/cg}$	38	38	35	34
df_e	566	481	372	300
k	10,2	8,6	7,4	6,4
Second set of data				
per ewe mated				
n	1 321	1 154	912	742
$df_{s/cg}$	305	300	270	236
df_e	979	817	608	475
k	3,7	3,3	2,9	2,7
per ewe conceived				
n	1 234	1 130	903	734
$df_{s/cg}$	297	297	269	235
df_e	900	796	600	468
k	3,5	3,2	2,9	2,7

Results and Discussion

Attention will first be given to genetic correlations between wool traits at 18 months and average reproduction over a number of lambing opportunities. Corresponding estimates for live mass and reproduction will then be discussed. Genetic correlations larger than twice their standard errors will be pointed out where applicable. This measure of accuracy must be considered arbitrary, especially when seen in relation to the prerequisites set by Tallis

(1959) for accurate genetic correlations. In general, the obtained estimates tended to be unaccurate, especially for wool traits. This result was expected, because genetic correlations tend to be unstable when one or both of the correlated traits has a low heritability (Young, Turner & Dolling, 1963; Lewer, Rae & Wickham, 1983). Genetic correlations involving Ec/Em and Ld/Lb, that showed little genetic variation (Cloete & Heydenrych, 1987) were particularly unstable. Negative between-sire variance components prevented the estimation of several genetic correlations for these traits, whilst some others were not within the theoretical limits for correlation coefficients. Genetic correlations involving Ec/Em and Ld/Lb are therefore not presented or discussed in detail.

Genetic correlations of fleece mass with reproduction

The genetic correlations of 18 months greasy and clean fleece mass with the average reproduction of ewes available for two, three, four and five lambing opportunities in the first and second sets of data (as specified previously) are presented in Tables 2 and 3 respectively. Estimates for the genetic correlations between greasy fleece mass and Lb/Ec ranged between 0,37 and -0,31 in the first set of data, and between 0,14 and -0,11 in the second set of data. Corresponding estimates for clean fleece mass ranged from 0,06 to 0,72 in the first set of data and from 0,06 to 0,22 in the second set of data. Only two out of 16 of these estimates were negative, whereas one estimate on the first set of data actually was twice as large as its standard error and two further estimates approached this level. The tendency towards a positive genetic correlation between clean fleece mass and multiple birth rate may possibly be related to the results obtained previously (Cloete & Heydenrych, 1986) and those of Barlow (1974). Both sources suggested the possibility of a higher frequency of multiple births in Merino ewes subjected to selection on clean fleece mass, although these results could not be confirmed by time trends in both investigations. Clarke (1972), on the other hand, reported a slight reduction in fleece mass as a correlated response to selection for fecundity in Romney ewes.

The genetic correlations between greasy fleece mass and Lb/Em were variable. Estimates obtained from the first set of data were consistently negative (Table 2). Corresponding estimates from the second set of data ranged between 0,17 and -0,15. The genetic correlations between clean fleece mass and Lb/Em ranged between 0,28 and -0,25 in the first set of data and between 0,08 and -0,07 in the second set of data (Table 3). The genetic correlation of fleece mass with number of lambs born, thus appears to be variable, as was also suggested by Turner (1972). There appears to be a tendency towards more negative estimates in the present

Table 2 The genetic correlations (r_g) and appropriate standard errors (SE) of 18 months greasy fleece mass with average reproduction over two to five lambing opportunities in the first and second sets of data

Item	Number of lambing opportunities			
	2	3	4	5
First set of data				
Lb/Ec				
r_g	- 0,306	0,332	0,365	0,293
SE	0,519	0,336	0,380	0,380
Lb/Em				
r_g	- 0,641	- 0,495	- 0,566	- 1,122
SE	0,620	0,638	0,671	4,695
Lw/Em				
r_g	- 0,998	- 0,274	- 0,576	-
SE	1,442	0,465	1,205	-
Second set of data				
Lb/Ec				
r_g	0,050	- 0,112	0,138	0,003
SE	0,232	0,244	0,261	0,314
Lb/Em				
r_g	0,036	- 0,145	0,168	- 0,087
SE	0,216	0,309	0,295	0,448
Lw/Em				
r_g	0,118	- 0,021	0,105	- 0,557
SE	0,257	0,301	0,317	0,737

\- Estimates could not be made because of negative between-sire variance components.

Table 3 The genetic correlations (r_g) and appropriate standard errors (SE) of 18 months clean fleece mass with average reproduction over two to five lambing opportunities in the first and second sets of data

Item	Number of lambing opportunities			
	2	3	4	5
First set of data				
Lb/Ec				
r_g	0,062	0,574	0,623	0,718[a]
SE	0,484	0,294	0,316	0,323
Lb/Em				
r_g	- 0,251	- 0,181	- 0,238	0,279
SE	0,534	0,574	0,617	1,920
Lw/Em				
r_g	- 0,680	- 0,281	- 0,432	-
SE	1,101	0,439	1,054	-
Second set of data				
Lb/Ec				
r_g	0,216	0,055	0,203	0,142
SE	0,233	0,245	0,252	0,278
Lb/Em				
r_g	0,076	- 0,069	0,064	- 0,041
SE	0,217	0,304	0,283	0,394
Lw/Em				
r_g	- 0,018	- 0,123	- 0,155	- 0,679
SE	0,253	0,299	0,301	0,691

\- Estimates could not be made because of negative between-sire variance components.

[a] Denotes estimates larger than twice their standard errors.

data, although none of these differed significantly from zero. Corresponding genetic correlations between fleece mass and total or average lamb production over a number of lambing seasons in the literature are 0,34 and 0,08 (Young, *et al.*, 1963, for greasy and clean fleece mass respectively), -0,13 and -0,25 (Shelton & Menzies, 1968), 0,09 and 0,27 (Basuthakur, Burfening, van Horn & Blackwell, 1973), 0,08 (Eikje, 1975) and -0,15 (More O'Ferrall, 1976). Positive correlations ranging from 0,05 to 0,19 were reported by Eikje (1975) in Norwegian sheep breeds belonging to age groups of 1 - 3 years, whilst a comparable estimate reported by Gjedrem (1966) was -0,25. Kennedy (1967) reported the only significant estimates of -0,52 for greasy fleece mass and -0,78 for clean fleece mass in 2-year old Merino ewes. There thus appears to be considerable variation in genetic correlations between wool mass and number of lambs born as reported in the literature. Turner (1972) contended that it should be possible to improve both these characteristics simultaneously, if attention is paid to both in the selection programme. It should perhaps be mentioned that Turner (1977) reported no correlated response in fleece mass in Merino ewes selected for reproduction rate, whilst a slight positive correlated response in Lb/Em was reported in Romney ewes selected on greasy fleece mass (Blair, Garrick, Rae & Wickham, 1985).

Genetic correlations between greasy fleece mass and Lw/Em ranged between -0,27 and -1,00 in the first set of data, and between 0,12 and -0,56 in the second set of data (Table 2). Corresponding correlations for clean fleece mass ranged between -0,28 and -0,68 in the first set of data, and between -0,02 and -0,68 in the second set of data (Table 3). Most of the obtained genetic correlations between fleece mass and Lw/Em were negative, although most estimates were small compared to their standard errors. These correlations are in general agreement with comparable estimates of -0,23 and -0,37 (Shelton & Menzies, 1968) and -0,34 (More O'Ferrall, 1976). Kennedy (1967) similarly reported estimates of -0,85 for greasy fleece mass and -1,13 for clean fleece mass in 2-year old Merino ewes, whereas Lewer, *et al.* (1983) reported estimates ranging from -0,05 to -0,45 for Perendale ewes at ages from 2 to 5 years. Gjedrem (1966) obtained a corresponding genetic correlation of -0,66 between wool mass and number of lambs weaned in Norwegian breeds. Positive estimates, on the other hand, were obtained by Young, *et al.*(1963), Basuthakur, *et al.* (1973) and Eikje (1975), whereas Blair, *et al.*(1985) reported a slight positive correlated response in Romney ewes. More research appears to be necessary to verify the exact value of the genetic correlation between fleece mass and Lw/Em. Lewer, *et al.* (1983) proposed a low negative genetic association between these traits in Perendale ewes, a tendency which is supported by some results in the literature. Barlow (1974) correspondingly reported a significantly lower weaning rate in his fleece plus ewes at 2 years of age, compared to fleece minus ewes.

Genetic correlations of fibre diameter with reproduction

Genetic correlations of fibre diameter at 18 months with average reproduction over two to five lambing opportunities are presented in Table 4. The genetic correlations of fibre diameter with Lb/Ec were positive in both sets of data and the estimate for the ewes available for four lambing opportunities in the first set of data was larger than twice its standard error. Corresponding estimates for Lb/Em were variable, ranging from 0,02 to -0,32 in the first set of data, and from 0,08 to 0,33 in the second set of data. The former estimates are in agreement with comparable negative estimates reported by Young, *et al.* (1963). Corresponding correlations with Lw/Em were positive but rather low. Comparable estimates for Lw/Em from the literature were consistently negative (Young, *et al.*, 1963; Lewer, *et al.*, 1983), but not significant. The genetic correlations of fibre diameter with rearing performance may thus be variable and possibly negative. A negative genetic correlation between these characteristics may be advantageous, as the demand on apparel wool markets increasingly favours finer fibres (Erasmus & Delport, 1985).

Table 4 Genetic correlations (r_g) and appropriate standard errors (*SE*) of 18 months fibre diameter with average reproduction over two to five lambing opportunities in the first and second sets of data

Item	Number of lambing opportunities			
	2	3	4	5
First set of data				
Lb/Ec				
r_g	0,299	0,537	0,813[a]	0,479
SE	0,506	0,371	0,368	0,470
Lb/Em				
r_g	- 0,275	- 0,316	0,018	- 0,115
SE	0,567	0,623	0,623	1,887
Lw/Em				
r_g	0,228	0,136	0,442	-
SE	0,867	0,467	1,055	-
Second set of data				
Lb/Ec				
r_g	0,153	0,281	0,411	0,212
SE	0,196	0,211	0,235	0,230
Lb/Em				
r_g	0,076	0,120	0,331	0,127
SE	0,197	0,269	0,254	0,323
Lw/Em				
r_g	0,254	0,097	0,114	0,037
SE	0,237	0,262	0,273	0,470

- Estimates could not be made because of negative between-sire variance components.

[a] Denotes estimates larger than twice their standard errors.

Genetic correlations of live mass with reproduction

Genetic correlations of mating mass at 1,5 - 5,5 years with subsequent reproduction at 2 - 6 years are presented in Table 5. In the following discussion age at lambing will be used to indicate age, instead of age at mating. Estimates for Lb/Ec ranged between 0,36 and 0,89 in the first set of data,

Table 5 Genetic correlations (r_g) and appropriate standard errors (*SE*) of mating mass with subsequent reproduction at ages 2 - 6 years in the first and second sets of data

Item	Age of ewe				
	2 years	3 years	4 years	5 years	6 years
First set of data					
Lb/Ec					
r_g	-	0,616[a]	0,892[a]	0,616	0,360
SE	-	0,306	0,248	0,675	0,367
Lb/Em					
r_g	-	0,952[a]	0,847	0,202	0,777
SE	-	0,455	0,503	0,339	0,496
Lw/Em					
r_g	-	0,692[a]	0,256	0,177	0,560
SE	-	0,325	0,529	0,703	0,759
Second set of data					
Lb/Ec					
r_g	0,112	0,053	0,667	0,687	- 0,073
SE	0,294	0,208	0,343	0,863	0,366
Lb/Em					
r_g	0,237	0,535[a]	-	0,336	0,582
SE	0,182	0,223	-	0,288	0,353
Lw/Em					
r_g	0,199	0,569[a]	0,098	0,230	-
SE	0,265	0,279	0,286	0,361	-

\- Estimates could not be made because of negative between-sire variance components.

[a] Denotes estimates larger than twice their standard errors.

whilst corresponding estimates in the second set of data were more variable, ranging between -0,07 and 0,69. The estimates for 3-and 4-year-old ewes in the first set of data reached a magnitude of larger than twice their standard errors. The results obtained in the first set of data were in agreement with comparable estimates of 0,44 and 0,78 in Blackface and Welsh ewes respectively (Purser, 1965). Forrest & Bichard (1974) published comparable estimates ranging between 0,23 and 0,46 for Clun Forest ewes at different ages.

Genetic correlations between mating mass and Lb/Em tended to be positive, and were larger than twice their standard errors in the 3-year-old ewes of both sets of data. The obtained estimate for 2-year-old ewes in the second set of data (0,24) was in agreement with the value of 0,20 reported by Kennedy (1967) for Merinos, but tended to be low compared to estimates of 0,47 (Young, *et al.*, 1963), 0,81 and 0,72 (Ch'ang & Rae, 1972) and 0,85 (More O'Ferrall, 1976) for Merino, Romney and Galway ewes respectively. Estimates of 0,95 and 0,54 obtained in 3-year-old ewes, on the other hand, were higher than the value of 0,16 reported by Young, *et al.* (1963). Most of the obtained estimates were higher than those reported for Clun Forest ewes of different age groups (Forrest & Bichard, 1974).

Genetic correlations between mating mass and Lw/Em were mostly positive, and larger than twice their standard errors in 3-year-old ewes of both sets of data. The genetic correlation of 0,20 between mating mass and reproduction at 2 years of age in the second set of data was somewhat higher than corresponding estimates of zero (Young, *et al.*, 1963) and 0,06 (Kennedy, 1967) for Merino ewes, but somewhat smaller than the estimate of 0,42 (More O'Ferrall, 1976) for Galway ewes. The estimates of 0,69 and 0,57 at 3 years of age in the first and second sets of data were higher than the value of 0,22 reported by Young, *et al.*, 1963.

Genetic correlations of 1,5 years mating mass with average reproduction over a number of lambing opportunities are presented in Table 6. The genetic correlation between 1,5 years mating mass and average lifetime Lb/Ec was consistently positive, ranging between 0,49 and 0,92 in the first set of data and between 0,25 and 0,49 in the second set of data. Five estimates were larger than twice their standard errors. These estimates are comparable to values of 0,44 for Blackface ewes and 0,78 for Welsh ewes (Purser, 1965), and tend to be higher than the estimate of 0,21 in the overall analysis on Clun Forest ewes (Forrest & Bichard, 1974). Genetic correlations of 1,5 years mating mass with average Lb/Em also tended to be positive, whilst two estimates in the second set of data were larger than twice their standard errors. The eight estimates presented in Table 6 ranged between 0,36 and 0,84, which were

Table 6 Genetic correlations (r_g) and appropriate standard errors (*SE*) of 1,5 years mating mass with average reproduction of ewes over two to five lambing opportunities in the first and second sets of data

Item	Number of lambing opportunities			
	2	3	4	5
First set of data				
Lb/Ec				
r_g	0,492	0,922[a]	0,787[a]	0,571[a]
SE	0,500	0,194	0,228	0,240
Lb/Em				
r_g	0,566	0,844	0,563	0,690
SE	0,318	0,466	0,483	1,003
Lw/Em				
r_g	0,666	0,248	0,083	-
SE	0,592	0,396	0,801	-
Second set of data				
Lb/Ec				
r_g	0,341	0,377[a]	0,485[a]	0,253
SE	0,195	0,174	0,180	0,178
Lb/Em				
r_g	0,356[a]	0,395	0,550[a]	0,362
SE	0,164	0,205	0,197	0,232
Lw/Em				
r_g	0,318	0,161	0,438	0,367
SE	0,243	0,235	0,231	0,329

\- Estimates could not be made because of negative between-sire variance components.

[a] Denotes estimates larger than twice their standard errors.

within the range of values reported by Young, *et al.* (1963), Shelton & Menzies (1968) and Ch'ang & Rae (1972), and were somewhat higher than comparable estimates published by Forrest & Bichard (1974) and More O'Ferrall (1976).

Corresponding genetic correlations of 1,5 years mating mass with Lw/Em were positive and ranged between 0,08 and 0,67 in the first set of data and between 0,16 and 0,44 in the second set of data. None of these estimates reached a magnitude of twice their standard errors. The obtained estimates were in general agreement with comparable values of 0,47 for Merino ewes (Young, *et al.*, 1963) and 0,35 to 0,44 for Rambouillet ewes (Shelton & Menzies, 1968), and tended to be higher than the low negative estimate of -0,19 for Galway ewes reported by More O'Ferrall (1976).

Results presented above indicate a positive genetic correlation between live mass and reproduction in general. These results are in agreement with literature cited and that reviewed by Turner (1972). When correlated responses to selection either for reproduction rate or for live mass are considered, this relationship appears to be more complicated. Selection for increased reproduction rate resulted in a small correlated response in live mass in Romney sheep (Clarke, 1972), and in Merino sheep (Turner, 1972), but not in Galway sheep (Hanrahan, 1976). Pattie (1965) similarly reported no correlated response in reproduction traits associated with selection for weaning mass, an observation which could be related to selection against litter size, as no adjustment for birth type was made. Rather similar results were presented by Hinch, Edey, Thwaites, Piper, Bindon & Kinghorn (1984) after 30 years of selection for and against weaning mass in Merinos. Lasslo, *et al.* (1985) reported a negative correlated response in the reproduction rate of Targhee sheep selected for 120-day mass. Turner (1972) contended that the only evidence of negligible genetic correlations of live mass with reproduction were obtained when live mass at young ages was considered. A positive genetic relationship of live mass with reproductive performance thus appears to be evident in sheep, provided that the live mass to be considered is not at an extremely young age. Selection for an increased 1,5-years mating mass will thus probably be associated with an increase in reproduction rate. Care must be taken not to discriminate against multiple born individuals, as it may result in reduced gains. The obtained results must also be seen in relation to results reviewed by Cockrem (1979), who contended that reproduction should be improved without an increase in live mass, as the higher maintenance requirements of larger ewes cancel some of the benefit of an increased reproduction on a total productivity basis.

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References

BARLOW, R., 1974. Selection for clean fleece mass in Merino sheep. II. Correlated responses to selection. *Aust. J. Agric. Res.* 25, 973.

BASUTHAKUR, A.K., BURFENING, P.J., VAN HORN, J.L. & BLACKWELL, R.L., 1973. A study of some aspects of lifetime production in Targhee and Columbia sheep. *J. Anim. Sci.* 36, 813.

BLAIR, H.T., GARRICK, D.J., RAE, A.L. & WICKHAM, G.A., 1985. Selection responses in New Zealand Romney sheep. 2. Selection for yearling greasy fleece weight. *N. Z. J. Agric. Res.* 28, 257.

CH'ANG, T.S. & RAE, A.L., 1972. The genetic basis of growth, reproduction, and maternal environment in Romney ewes. II. Genetic covariation between hogget characters, fertility and maternal environment of the ewe. *Aust. J. Agric. Res.* 23, 149.

CLARKE, J.N., 1972. Current levels of performance in the Ruakura fertility flock of Romney sheep. *Proc. N. Z. Soc. Anim. Prod.* 32, 99.

CLOETE, S.W.P. & HEYDENRYCH, H.J., 1986. Factors affecting reproduction in Merino ewes of the Tygerhoek flock. *S. Afr. J. Anim. Sci.* 16, 36.

CLOETE, S.W.P. & HEYDENRYCH, H.J., 1987. Genetic parameters for reproduction rate in the Tygerhoek Merino flock. 1. Heritability. *S. Afr. J. Anim. Sci.* 17, 1.

COCKREM, F.R.M., 1979. A review of the influence of liveweight and flushing on fertility made in the context of efficient sheep production. *Proc. N. Z. Soc. Anim. Prod.* 39, 23.

EIKJE, E.D., 1975. Studies on sheep production records. VII. Genetic, phenotypic and environmental parameters for productivity traits of ewes. *Acta Agric. Scand.* 25, 242.

ERASMUS, G.J. & DELPORT, G.J., 1985. 'n Kritiese beskouing van seleksiedoelwitte by wolskape. Verrigtinge van 'n simposium oor skaap- en vleisbeesteling. Januarie 1985, Pretoria, 109.

FORREST, P.A. & BICHARD, M., 1974. Analysis of production records from a lowland sheep flock. 3. Phenotypic and genetic parameters for reproductive performance. *Anim. Prod.* 19, 33.

GJEDREM, T., 1966. Selection index for ewes. *Acta Agric. Scand.* 16, 21.

HANRAHAN, J.P., 1976. Response to selection for litter size in Galway sheep. *Ir. J. Agric. Res.* 15, 291.

HARVEY, W.R., 1970. Estimation of variance and covariance components in the mixed model. *Biometrics* 26, 485.

HARVEY, W.R., 1977. User's guide for LSML76 - Mixed model least squares and maximum likelihood computer program. Ohio State University, Ohio, USA.

HARVEY, W.R., 1982. Mixed model capabilities of LSML76. *J. Anim. Sci.* 54, 1279.

HINCH, G.N., EDEY, T.N., THWAITES, G.J., PIPER, L.R., BINDON, B.M. & KINGHORN, B.P., 1984. Ovulation rate responses to long term weaning weight selection in Merino's. *Proc. Annual Conf. Aust. Soc. Reprod. Biol.* 16, 71.

KENNEDY, J.P., 1967. Genetic and phenotypic relationships between fertility and wool production in 2-year-old Merino sheep. *Aust. J. Agric. Res.* 18, 515.

LASSLO, L.L., BRADFORD, G.E., TORELL, D.T. & KENNEDY, B.W., 1985. Selection for weaning weight in Targhee sheep in two environments. II. Correlated effects. *J. Anim. Sci.* 61, 387.

LEWER, R.P., RAE, A.L. & WICKHAM, G.A., 1983. Analysis of records of a Perendale flock. IV. Estimates of genetic and phenotypic parameters for mature ewes. *N. Z. J. Agric. Res.* 26, 309.

MORE O'FERRALL, G.J., 1976. Phenotypic and genetic parameters of productivity in Galway ewes. *Anim. Prod.* 23, 295.

PATTIE, W.A., 1965. Selection for weaning weight in Merino sheep. 2. Correlated responses in other production characteristics. *Aust. J. Exp. Agric. Anim. Husb.* 5, 361.

PURSER, A.F., 1965. Repeatability and heritability of fertility in hill sheep. *Anim. Prod.* 7, 75.

ROUX, C.Z. & SCHOLTZ, M.M., 1984. Breeding goals for optimal total life cycle production systems. Proc. 2nd World Congress on Sheep and Beef Cattle Breeding (1984), 444.

SCHOLTZ, M.M. & ROUX, C.Z., 1984. Correlated responses to selection for growth, size and efficiency. Proc. 2nd. World Congress on Sheep and Beef Cattle Breeding (1984), 433.

SHELTON, M. & MENZIES, J.W., 1968. Genetic parameters of some performance characteristics of range fine-wool ewes. *J. Anim. Sci.* 27, 1219.

TALLIS, G.M., 1959. Sampling errors of genetic correlation coefficients calculated from analysis of variance and covariance. *Aust. J. Stat.* 1, 35.

TURNER, HELEN NEWTON, 1972. Genetic interactions between wool, meat and milk production in sheep. *Anim. Breed. Abstr.* 40, 621.

TURNER, HELEN NEWTON, 1977. Australian sheep breeding research. *Anim. Breed. Abstr.* 45, 9.

TURNER, HELEN NEWTON & YOUNG, S.S.Y., 1969. Quantitative genetics in sheep breeding. Ithaca, New York, USA.

YOUNG, S.S.Y., TURNER, HELEN NEWTON, & DOLLING, C.H.S., 1963. Selection for fertility in Australian Merino sheep. *Aust. J. Agric. Res.* 14, 460.