Assessment of different selection criteria for reproduction rate in Dormer and S.A. Mutton Merino sheep. 1. Birth type and early reproductive performance of the ewe

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Reproduction data of 839 Dormer and 741 S.A. Mutton Merino ewes were analysed in order to evaluate certain conventional selection criteria for reproduction rate in sheep. Results indicated that, although a positive response in reproduction rate can be expected for the S.A. Mutton Merino by using birth type of breeding ewes as a selection criterion, only a marginal response can be expected for Dormer ewes. These differences between breeds are apparently due to differences in the heritability of fecundity (0,26 *vs* 0,04 for the S.A. Mutton Merino and Dormer respectively). Owing to the relatively high repeatability estimation for fertility obtained for both breeds in the present study (0,17 *vs* 0,15 for the S.A. Mutton Merino and Dormer respectively), the culling of ewes that fail to lamb during their first lambing season is recommended in order to improve, within generations, the reproduction rate. Owing to differences in the repeatability of fecundity between the two breeds, the use of the number of lambs born during the first lambing season as a selection criterion had a further significant effect on the subsequent reproductive performance of the S.A. Mutton Merino ewes only. Results further revealed that early reproductive performance after the first two lambing seasons as well as a combination of early reproductive performance and birth type of the ewe can be used effectively as a selection criterion to improve overall reproductive performance in sheep flocks.
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Reproduksiegegewens van 839 Dormer-en 741 S.A. Vleismerino-ooie is ontleed ten einde sekere konvensionele seleksiemaatstawwe vir reproduksietempo by skape te evalueer. Resultate dui daarop dat, in teenstelling met 'n positiewe verbetering in reproduksie by die S.A. Vleismerino, slegs 'n marginale respons by Dormerooie verwag kan word deur teeltooie se geboortestatus as seleksiemaatstaf te gebruik. Hierdie verskille tussen rasse is waarskynlik te wyte aan die verskille in oorerflikheid van fekunditeit (0,26 *vs* 0,04 vir die S.A. Vleismerino en Dormer onderskeidelik). Op grond van die relatief hoë herhaalbaarheidsberamings van vrugbaarheid by albei rasse (0,17 *vs* 0,15 vir die S.A. Vleismerino en Dormer respektiewelik) word die uitskot van ooie wat tydens hul eerste lamseisoen oorslaan, aanbeveel ten einde reproduksietempo binne generasies te verhoog. Die gebruik van aantal lammers gebore tydens die eerste lamseisoen as seleksiemaatstaf vir verhoogde reproduksietempo binne generasies sou, weer eens as gevolg van verskille tussen rasse in die herhaalbaarheid van fekunditeit, 'n verdere betekenisvolle invloed op die latere leeftydsreproduksieprestasie van slegs S.A. Vleismerino-ooie hê. Resultate dui verder daarop dat vroeë reproduksieprestasie na twee lamseisoene asook 'n kombinasie van vroeë reproduksieprestasie en geboortestatus van die ooi voordelig aangewend kan word ten einde reproduksieprestasie van skaapkuddes te verhoog.
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Introduction

The efficiency of selection for the genetic improvement of reproduction rate in sheep, both within existing and in future generations, is to a large extent dependent upon the early and accurate identification of genetically superior animals. Despite certain limitations as outlined by Kritzinger, Stindt & Van der Westhuysen (1984), selection criteria, based on the birth type of breeding animals and number of lambs born to ewes during their first lambing season, have been found a particular practical application for the genetic improvement of reproduction rate in sheep (Turner, 1969).

Comparisons of the reproductive performance of single and multiple born ewes have, amongst others, been made by Dun & Grewal (1963) for Australian Merinos, Wallace (1958, 1964) for the Romney Marsh of New Zealand, Van der Westhuysen (1973) for South African Merinos, Van der Merwe (1976) for the Elsenburg Dormer and Baharin & Beilhartz (1977) for Corriedale ewes. The finding that multiple born ewes usually produced more lambs than single born ewes, though the differences were not great, led to the general recommendation that the most effective method for improving reproduction rate in sheep is to select for multiple births (Turner, 1969). Despite the relatively low heritability estimates for reproduction rate (Turner, 1969), and thus an expected slow genetic response, Turner (1978) cited evidence that the extremely high reproduction rate in certain highly prolific sheep breeds like the Finnish Landrace and the Romanov was the result of strict selection for multiple births. The encouraging improvement in reproduction rate reported for the Romney in New Zealand (Wallace, 1958, 1964; Clarke, 1972), the Merino in Australia (Turner, Hayman, Triffitt & Prunster, 1962; Turner, 1966, 1978) and the S.A. Mutton Merino in South Africa (Conroy, 1961) may also be attributed to continuous selection for multiple births.

Gain through selection in the current flock is a function of both the proportion of ewes culled and the difference in subsequent lifetime reproductive performance between the selected and culled groups. Turner (1968, cited by Turner, 1969) concluded from results of various relevant studies that subsequent lifetime reproduction, despite the relatively low repeatability estimation for reproduction rate in sheep, was positively related to early reproductive performance. Although various researchers (Young, Turner & Dolling, 1963; Turner, 1966; Van der Westhuysen, 1973; Lewer & Allison, 1980) reported greater differences in subsequent performance between ewes producing two or one lambs initially, compared with those producing one or no lambs, Turner (1968, cited by Turner, 1969)

stated that this was not consistently the case and that the magnitude of these differences was often reversed. Van der Merwe (1976) and Fogarty, McGuirke & Nicholls (1976) in fact reported much higher repeatability estimations for fertility (the ewe's ability to produce a lamb) than for fecundity (number of lambs born per lambing) in Dormer and Border Leicester ewes, respectively.

By relating reproductive performance of Merino ewes at two and three years of age to their average subsequent lifetime reproduction, Van der Westhuysen (1973) and Cloete, Heydenrych & Du Plessis (1983) concluded that reproductive performance after two lambing seasons was a better predictor of reproductive performance in subsequent years than reproductive performance after only one lambing season. These results were in agreement with those reported by Turner (1966) who demonstrated that ewes which had at least one multiple birth during their first three lambings, produced an average of 0,55 more multiple births during the next three lambing seasons than those which had no multiple birth during their first three lambings.

Fenj & Petrov (1971, cited by Van der Merwe, 1976) further demonstrated that selection of breeding ewes based simultaneously on both birth type and early reproductive performance held definite advantages. For Kazahk ewes classified into the following four groups according to birth type and reproductive performance during the first lambing season namely, single born/one lamb; single born/two lambs; twin born/one lamb; twin born/two lambs, these authors reported 1,36; 1,44; 1,50 and 1,60 lambs born per ewe mated during the second lambing season.

Owing to the particular importance of improved reproduction rate in sheep, especially in the case of slaughter lamb production, the aim of this study was to compare the various conventional selection criteria as a means of improving reproduction rate in the Elsenburg Dormer and S.A. Mutton Merino flocks.

Experimental procedure

Material and data used in this study originated from the Elsenburg Dormer and S.A. Mutton Merino flocks of which the history and development have been described in detail by Van der Merwe (1976) and Vosloo (1967) respectively. The managerial procedures practised for both flocks under investigation are described by Kritzinger (1982). Group mating was performed annually during early summer (from mid November) for a six week period.

Observations were made on the performance of 839 Dormer ewes (born during the period 1954 to 1974) and 741 S.A. Mutton Merino ewes (born during the period 1958 to 1975). Only ewes that completed at least two lambing seasons were included in the analysis. Ewes that failed to lamb during each of their first two lambing seasons were ignored because such animals usually were culled.

To evaluate the reproduction data, ewes were classified on the basis of (i) birth type; (ii) reproductive performance (number of lambs born) after their first lambing season; (iii) reproductive performance (number of lambs born) after their first two lambing seasons; and (iv) a combination of birth type with reproductive performance after the first lambing season considering the following subclasses; (a) single born/no lamb; (b) single born/one lamb; (c) single born/two or more lambs; (d) twin born/no lamb; (e) twin born/one lamb; (f) twin born/two or more lambs.

Subsequent lifetime reproductive performance of individual ewes was expressed in terms of the number of lambs born per ewe mated (lambing rate) and as the number of lambs born per ewe lambed (fecundity).

Analyses of variance in a one-way classification with uneven numbers were performed to study the significance of the various selection parameters on subsequent lifetime reproduction.

The ewe's reproductive performance as a regression on her own birth type (mother's performance) was used as an estimate of heritability (h^2) of fecundity as described by Van der Merwe (1976). Neither the dam's age nor the ewe's age was taken into account. The heritability estimations obtained thus presented the average overall dam and ewe ages and were calculated from the formula

$$h^2 = \frac{2R}{S_o}$$ where S = selection differential
R = response (difference in performance of ewes born as single or twin).

Repeatability (t) of reproduction rate was estimated by regression of the average number of lambs born in subsequent years on the number of lambs born during a specific reference year as proposed by Lush (1956) and described by Turner & Young (1969). Repeatabilities of fertility and fecundity were estimated by allotting ewes, according to number of lambs born during the first lambing season, into classes of 0, 1 or 2. The average subsequent lifetime reproduction for each class was calculated and the differences between classes 0 and 1 and classes 1 and 2 were used as repeatability estimations for fertility and fecundity respectively.

Results

The relationship between birth type of ewes and their lifetime reproduction is presented in Table 1 for both the Dormer and S.A. Mutton Merino flocks.

Table 1 Effect of birth type of Dormer and S.A. Mutton Merino ewes on lifetime reproductive performance

	Birth type		
	Single born	Multiple born	F-value
Dormer			
lambs born/ewe mated	1,21	1,23	0,306 NS
lambs born/ewe lambed	1,40	1,46	3,951[a]
number of ewes	393	446	
S.A. Mutton Merino			
lambs born/ewe mated	1,32	1,45	8,792[b]
lambs born/ewe lambed	1,57	1,65	6,023[a]
number of ewes	183	511	

NS Not significant at $P \leqslant 0,10$
[a] $P \leqslant 0,05$
[b] $P \leqslant 0,01$

From these results it is evident that birth type for both breeds exerts a significant effect ($P \leqslant 0,05$) on the lifetime reproductive performance of ewes in terms of number of lambs born per ewe lambed. Twin born Dormer and S.A. Mutton Merino ewes produced on average, respectively 0,06 and 0,08 more lambs per ewe lambed than did single born ewes. However, the average number of lambs born per mating showed a marked difference between the two breeds. Twin born S.A. Mut-

ton Merino ewes produced on average 0,13 more lambs per year than did single born ewes which resulted in the relatively high heritability estimation of 0,26 for fecundity in this breed. In Dormer ewes, on the other hand, the difference of 0,02 lambs per year in favour of twin born ewes was not significant, resulting in an extremely low heritability estimation of 0,04 for fecundity in this breed.

The relationship between reproductive performance during the first lambing season and subsequent lifetime reproduction (Table 2) were basically similar for the two breeds. For both breeds, ewes having produced twins during their first lambing season, produced significantly ($P \leqslant 0,01$) more lambs per ewe lambed in subsequent years than either ewes that failed to lamb, or ewes that produced a single lamb during their first lambing season. Ewes that failed to lamb during their first lambing season, consistently exhibited a small advantage in terms of number of lambs born per conception in subsequent years, over ewes that produced one lamb in their first lambing season. Regarding the number of lambs born per mating, statistically significant differences between ewes which produced 0 or 1 and 1 or 2 lambs during the first lambing season were found for both breeds. The magnitude of those differences, however, differed for the two breeds resulting in repeatability estimates for fertility and fecundity of 0,15 and 0,06 for the Dormer and 0,17 and 0,19 for the S.A. Mutton Merino, respectively. The fact that ewes which produced one lamb during the first lambing season, subsequently produced more lambs per mating that did ewes that failed to lamb during their first lambing, was apparently responsible for the relatively high repeatability estimate for fertility in both breeds, despite the latter group's advantage in terms of fecundity.

Table 2 Effect of reproductive performance after one lambing season on subsequent lifetime reproduction of Dormer and S.A. Mutton Merino ewes

	Number of lambs born during first lambing season			
	0	1	2	F-value
Dormer				
lambs born/ewe mated	1,13	1,28	1,34	6,233[b]
lambs born/ewe lambed	1,47	1,44	1,57	7,675[b]
number of ewes	133	490	216	
S.A. Mutton Merino				
lambs born/ewe mated	1,21	1,38	1,57	16,248[b]
lambs born/ewe lambed	1,68	1,59	1,82	6,368[b]
number of ewes	94	317	330	

[b] $P \leqslant 0,01$

The pooled repeatability and sampling variance of lambs born per ewe mated, calculated from Table 2 were 0,105 ± 0,014 and 0,180 ± 0,014 for the Dormer and S.A. Mutton Merino flocks respectively.

The relationship between reproductive performance of ewes after two lambing seasons and subsequent lifetime reproduction is presented in Table 3.

From these results it is clear that, despite a relatively high fecundity in subsequent years, ewes having produced only one lamb during their first two lambing seasons tended to be less fertile in later years, especially in the case of S.A. Mutton Merino ewes. For both breeds the number of lambs born per mating during subsequent lambing seasons was positively related to the number of lambs born during the first two lambing seasons. The pooled repeatability and sampling variance calculated from the results in Table 3 were 0,105 ± 0,064 and 0,190 ± 0,177 for the Dormer and S.A. Mutton Merino flocks, respectively. These values are comparable to those calculated after one lambing season.

Table 3 Effect of reproductive performance after two lambing seasons on subsequent lifetime reproduction of Dormer and S.A. Mutton Merino ewes

	Number of lambs born after two lambing seasons				
	1	2	3	4	F-value
Dormer					
lambs born/ewe mated	1,22	1,30	1,39	1,56	9,811[b]
lambs born/ewe lambed	1,54	1,48	1,64	1,73	1,586 NS
number of ewes	96	273	201	66	
S.A. Mutton Merino					
lambs born/ewe mated	1,03	1,41	1,57	1,60	9,976[b]
lambs born/ewe lambed	1,62	1,63	1,74	1,78	3,193[a]
number of ewes	34	137	181	194	

NS Not significant at $P \leqslant 0,10$

[a] $P \leqslant 0,05$

[b] $P \leqslant 0,01$

Calculated from the data in Table 3, the differences between number of lambs born per mating and lambs born per ewe lambed for ewes having at least one multiple birth during their first two lambing seasons and those without multiple births, were 0,14 and 0,14 for the Dormer and 0,26 and 0,13 for the S.A. Mutton Merino flocks, respectively.

The relationship between reproductive performance during the first lambing season and subsequent lifetime reproduction for both single and twin born ewes is presented in Table 4.

For both breeds twin born ewes in all the subclasses outperformed single born ewes in terms of lambs born per conception and lambs born per mating, except in the case of ewes that failed to lamb during their first lambing season. In this case single born ewes subsequently produced more lambs per mating than did twin born ewes. The relatively low subsequent lifetime reproduction of twin born ewes that failed to lamb is surprising in view of the extremely high fecundity of such ewes found in the present study.

Discussion

In accordance with results of similar studies (Turner, 1969), the results obtained indicated that a positive improvement in reproduction rate can be expected for the S.A. Mutton Merino by using birth type of breeding ewes as a selection criterion. In contrast to this finding, but in agreement with Van der Merwe (1976), in the Dormer breed this selection criterion offered only a marginal response in terms of number of lambs born per mating. These differences between breeds are apparently due to differences in the heritability of fecundity (0,26 *vs* 0,04 for the S.A. Mutton Merino and Dormer respectively)

Table 4 Effect of reproductive performance after one lambing season on subsequent lifetime reproduction of single and twin born Dormer and S.A. Mutton Merino ewes

	Number of lambs born during first lambing season						
	Single born			Twin born			
	0	1	2	0	1	2	F-value
Dormer							
lambs born/ewe mated	1,17	1,25	1,26	1,10	1,30	1,42	3,233[b]
lambs born/ewe lambed	1,42	1,41	1,49	1,52	1,46	1,64	5,559[b]
number of ewes	61	226	106	72	264	110	
S.A. Mutton Merino							
lambs born/ewe mated	1,29	1,25	1,54	1,18	1,43	1,59	7,934[b]
lambs born/ewe lambed	1,65	1,48	1,76	1,70	1,62	1,84	2,955[a]
number of ewes	29	81	73	65	236	257	

[a] $P \leqslant 0,05$
[b] $P \leqslant 0,01$

found in the present study. This confirmed earlier findings of Van der Merwe (1976) and Vosloo (1967) who reported on the heritability of fecundity in the Dormer and S.A. Mutton Merino breeds respectively.

The reason for the difference in heritability of litter size between the two breeds can only be speculated upon. Various researchers (Young *et al.*, 1963; Purser, 1965; Vosloo, 1967; Van der Merwe, 1976) drew attention to the effect of ewe age on heritability estimates for fecundity. Van der Merwe (1976) further demonstrated that dam's age also exerted a significant effect on the response gained through selection based on the ewe's birth type. When considering the reproductive performance of the progeny from first lambing Dormer ewes (dams), this author found that during their first lambing season single born ewes produced more lambs per mating than twin born ewes, while twin born ewes from older Dormer ewes consistently produced more lambs per mating than did single born ewes. Van der Merwe (1976) thus concluded that the heritability of fecundity for ewes born from first lambing dams, was extremely low. As suggested by Dun & Grewal (1963) this was possibly due to a retarded growth of multiplets comparing to single born lambs. Evidence of the effects of dam's age on the heritability of fecundity for S.A. Mutton Merino lambs may possibly explain the differences in heritability estimations of litter size between the two breeds.

The results of the present study relating to selection progress of reproduction rate in the current flock revealed that early reproductive performance, either after one or two lambing seasons, as well as a combination of early reproductive performance and birth type of the ewe can be used effectively as selection criteria to improve overall reproductive performance in sheep flocks.

Young *et al.* (1963), Turner (1966), Van der Westhuysen (1973) and Lewer & Allison (1980) predicted only a marginal response to selection for fertility and a much higher response to selection for fecundity. In contrast, relatively high repeatability estimates of fertility were obtained for both breeds in the present study (0,17 *vs* 0,15 for the S.A. Mutton Merino and Dormer respectively). The culling of ewes that failed to lamb during their first lambing season was thus advisable for both breeds in order to improve the reproduction rate within the current flock. However, owing to differences in the repeatability of litter size between the two breeds (0,19 *vs* 0,06 for the S.A. Mutton Merino and Dormer respectively), the use of litter size during the first lambing season as a selection criterion had a significant effect on the subsequent reproductive performance of the S.A. Mutton Merino ewes only. Findings regarding the selection response in Dormer ewes based on early reproductive performance were similar to those reported by Van der Merwe (1976) and Fogarty *et al.* (1976) for Dormer and Corriedale ewes, respectively. These authors also found the repeatability of fertility higher than that of fecundity.

By relating reproductive performance of ewes after two lambing seasons to their average subsequent reproductive performance, pooled repeatability estimates similar to those calculated after only one lambing season were found. Higher repeatability estimates, however, were demonstrated when relating the reproductive performance of ewes with at least one multiple birth during their first two lambing seasons to those without multiple births. These findings are in agreement with results reported by Turner (1966), Van der Westhuysen (1973) and Cloete *et al.* (1983) and suggest that this criterion can be beneficially applied for improving reproduction rate in sheep. A possible disadvantage, however, is the fact that selection in this case can be performed only after at least two lambing seasons. Results of the present study further revealed that for both breeds ewes producing only one (or less) lamb after two lambings must be strictly discriminated against and that preference should be given to ewes which produced three or more lambs.

Selection of breeding ewes based on own birth type and early reproductive performance (after one lambing season) proved beneficial for both breeds. Single born S.A. Mutton Merino ewes which produced twin lambs in their first lambing season outperformed single born ewes which were either barren or produced only one lamb. In fact, those former group of ewes reproduced almost as well as twin born ewes which produced twin lambs in their first lambing season. In Dormer ewes, on the other hand, twin born ewes which produced either one or more lambs during their first lambing season outperformed single born ewes with similar early reproduction. Compared to the results reported elsewhere in this paper where no significant differences in lifetime reproductive performance between single and twin born Dormer ewes could be demonstrated, this discrepancy can be explained by the extremely low reproduc-

tive performance of twin born ewes that failed to lamb during the first lambing season compared to that of single born ewes that failed to lamb early in life. From these results it is concluded that for both breeds, ewes having been barren in their first lambing season should be discriminated against and preference should be given to twin born ewes that produced at least one lamb during their first lambing season.

Conclusions

Results revealed that positive gains in reproductive performance of sheep can be accomplished using conventional selection criteria based on the ewe's birth type and her early reproductive performance. Breed differences, however, determine the selection criterion of preference.

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