

Studies on small ruminant breeds with inherent differences in fibre production and ewe productivity 1. Relationship between ewe productivity and wool production potential

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Ewe productivity, as affected by varying wool production potential in different environments was studied in three woolled sheep flocks. Production and reproduction data collected in the Carnarvon Afrino flock (AC) between 1979 and 1992, as well as data of the Carnarvon Merino flock (MC) collected between 1962 and 1983 were used to represent production in a semi-desert environment. Similar data collected in the Grootfontein Merino stud (MG) between 1966 and 1993 were used to represent production under favourable nutritional conditions. Only data concerning the first three lambing opportunities of 609, 2234 and 1616 ewes of AC, MC and MG respectively, were included in the analysis. Wool production potential (WPP), defined as wool produced per kg of body weight from 6 to 18 months of age was 4.21, 8.15 and 11.24% for AC, MC and MG respectively. Ewe productivity (EP), defined as total weight of lamb weaned over the first three lambing opportunities was 116.8, 38.8 and 90.2 kg for the respective flocks. Within all three flocks, EP was negatively related ($p < 0.01$) to WPP. It is concluded that selection programmes with the net result of increasing WPP may have a detrimental effect on ewe productivity irrespective of breed and environment. Apparently, the concept of adaptation to adverse environmental conditions needs to be duly considered in selection programmes of sheep. The provision of optimum nutritional conditions, such as diets with high levels of grain, to stud animals should also be reconsidered, especially where the progeny of these animals have to produce under less favourable conditions.

Die invloed van wolproduksiepotensiaal op ooiproduktiwiteit is in drie wolskaapkuddes ondersoek. Produksie en reprodusiedata wat tussen 1972 en 1992 in die Carnarvon Proefplaas se Afrinokudde (AC) en tussen 1962 en 1983 in die Carnarvon Proefplaas se Merinokudde (CM) ingesamel is, is gebruik as voorbeeld van produksiegegewens in 'n sub-optimale halfwoestyn omgewing. Soortgelyke data wat tussen 1966 en 1993 in die Grootfontein Merinostoot (MG) ingesamel is, is gebruik as voorbeeld van produksiegegewens onder gunstige voedingstoestande. Slegs data ten opsigte van die eerste drie lamkase van 609, 2234 en 1616 ooie van AC, MC en MG onderskeidelik, is in die ontleding ingesluit. Wolproduksiepotensiaal (WPP), gedefinieer as wolproduksie per kg liggaamsmassa vanaf 6 tot 12 -maande ouderdom was 4.21, 8.15 en 11.24% vir AC, MC en MG onderskeidelik. Ooiproduktiwiteit (EP), gedefinieer as totale masse lam gespeen oor die eerste drie lamkase, was 116.8, 38.8 en 90.2 kg vir die onderskeie kuddes. Ooiproduktiwiteit was binne al drie kuddes negatief verwant ($p < 0.01$) aan WPP. Gevolglik kan verwag word dat seleksieprogramme, met die netto resultaat van verhoogde WPP, 'n nadelige invloed op ooiproduktiwiteit sal hê, ongeag ras of omgewing. Dit blyk dat aanpasbaarheid by die omgewing egter tydens seleksie van alle skape in ag geneem behoort te word. Voorts kan die verskaffing van optimale voedings-toestande, soos diëte met hoë konsentrasies grane, aan stoediere bevestigte word, veral waar die nageslag van hierdie diere onder minder gunstige toestande moet produseer.

Keywords: wool production, ewe productivity, environment

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Introduction

Adaptation of animals to any environment is reflected in reproduction, survival and growth. It is important for small stock farmers in semi-desert regions to farm with animals well adapted to such an environment, to ensure maximum production with minimum input costs. In the past, adaptation to arid conditions has largely been ignored in selection programmes and selection of rams was performed almost exclusively under optimum feeding conditions. Fibre-producing small stock fulfill a vital role in agriculture of arid regions. The substantial evidence obtained from practice, namely, that high fibre-producing breeds are less adapted to sub-optimum environments, is therefore of great concern to the fibre industry. In this regard it has, for example, been shown that the Angora goat, presumably one of the highest fibre-producing small stock breeds in the world, is very susceptible to adverse environmental conditions (Wentzel *et al.*, 1974; Wentzel *et al.*, 1976; Wentzel *et al.*, 1979; Wentzel, 1987). Furthermore, several reports on genetic correlations between wool production and reproduction rate indicate an inverse relationship between these production functions (Cloete & Olivier, 1995; Fogarty, 1995).

Wool production potential expressed as wool produced per unit of body weight, is considered to be a more suitable means of comparing the genetic potential for fibre production in different wool sheep breeds in different environments (Herselman & King, 1993) than wool production *per se*. Conclusive evidence of a negative relationship between hardiness and wool production potential has been reported by Herselman *et al.* (1993). In this study, five genotypes of sheep were developed by crossbreeding Merino ewes with Merino, Dohne Merino, SA Mutton Merino, Afrino and Ronderib Afrikaner rams and the performance of the various genotypes compared. From these results it was evident that ewe productivity decreased sharply with increased wool production potential. Recently, it has also been shown (Cloete & Olivier, 1995) that when the progeny of two genotypes of Merino rams mated to commercial Merino ewes was raised under marginal Karoo veld, the genotype which had been selected for wool production was out-produced (wool production and body weight) by the group not selected for wool production. However, when the same progeny were kept on a high level of nutrition, the selected group produced more wool and had the highest body weight. The animals with a high wool production potential were apparently unable to realise their potential under a regime of sub-optimum nutrition. On account of these results, the practise of selecting woolled sheep under favourable conditions for use in extensive environments is seriously questioned (Cloete & Olivier, 1995).

The objective of this study was to investigate the apparent negative relationship between wool production potential and adaptation to sub-optimum environments within flocks.

Material and Methods

Data collected in the Carnarvon Afrino flock (AC) between 1972 and 1992, as well as data of the Carnarvon Merino flock (MC) collected between 1962 and 1983 were used. The average annual rainfall at the Carnarvon Experimental station is 209 mm and occurs mainly during autumn. The official grazing capacity is 5.5 ha per small stock unit. The vegetation consists mainly of sparsely populated Karoo shrubs and some grasses. Temperatures are typical of a semi-desert environment and vary between -9 and 39°C. Detailed descriptions of experimental and selection procedures are given by Snyman *et al.* (1995a) for the Afrino flock and by Erasmus *et al.* (1990) for the Merino flock. Similar data collected in the Grootfontein Merino stud (MG) between 1966 and 1993 were also used. This stud is kept under relatively favourable nutritional conditions which include the availability of irrigated pastures and supplementary feeding whenever needed.

For analysis of the relationship between wool production potential (WPP) and ewe productivity (EP), 609, 2934 and 1616 ewe records were used from AC, MC and MG respectively. Only data

related to the first three lambing opportunities of each ewe were included in the analysis. Best linear unbiased prediction (BLUP) of breeding values for clean fleece weight and body weight at 18 months of age were obtained as back solutions in the DFREML programme of Meyer (1991) and were used for the estimation of (co)variance components for Afrino (Snyman *et al.*, 1995b) and Merino sheep (Olivier *et al.*, 1994; Snyman *et al.*, 1996). Subsequently, these breeding values were corrected for the genetic trend. Adjusted clean fleece weight (CFWa) and body weight (BWA) for each animal were then obtained by adding the corrected breeding value to the overall mean of each trait. Wool production potential (WPP) was calculated as CFWa divided by BWA and expressed as a percentage.

Ewe productivity (EP), defined as the total weaning weight produced per ewe over a specific time, was calculated as follows: within each lambing season, weaning weight for all lambs was corrected to 120 days followed by least-squares corrections for sex. No corrections were made for birth status. Subsequently, total weight of lamb weaned by each ewe in each lambing season was calculated by adding the corrected weaning weight for all lambs weaned by each ewe in that specific lambing season. EP over three parities, for example, was calculated by adding total weight of lamb weaned for the first, second and third parities. EP was corrected for year of birth of the ewe. As the number of lambs weaned largely contributed to EP values, EP was not normally distributed and had a categorical nature. To overcome this, ewe records were ranked on WPP and then grouped into groups of 50 for regression purposes.

For each group, the mean of each trait was then calculated and these means were used in regression analysis of EP on BW, CFW and WPP respectively. Correlations between BWA and CFWa were calculated for each flock. Regression and correlation analysis were performed using the REG and CORR procedures of SAS (Littell *et al.*, 1991) respectively.

Results

The mean BW, CFW and WPP of ewes at 18 months of age, as well as EP over three lambing seasons are presented in Table 1.

Under similar environmental conditions at Carnarvon Experimental Station, Merino ewes weaned only 38.3 kg of lamb over three lambing opportunities, compared to 116.8 kg for Afrino ewes. The results in Table 1 are in accordance with previous reports (Cloete & Olivier, 1995; Herselman *et al.*, 1993) which revealed lower reproduction rates in high fibre-producing genotypes. The large difference in EP between the two breeds at Carnarvon can be ascribed to Merino ewes being less adapted to the harsh environment. This was also reflected in relatively low BW and CFW in these Merino ewes when compared to the values obtained in the Grootfontein Merino stud (Table

Table 1 Mean BW, CFW and WPP of Merino and Afrino ewes at 18 months of age, as well as EP over three lambing seasons

	Afrino	Merino	
	Carnarvon	Carnarvon	Grootfontein
n	609	2234	1616
BW (kg)	47.9 ± 0.100	32.0 ± 0.04	42.8 ± 0.05
CFW (kg)	2.01 ± 0.009	2.60 ± 0.003	4.8 ± 0.006
WPP (%)	4.21 ± 0.02	8.15 ± 0.01	11.24 ± 0.02
EP (kg)	116.8 ± 1.28	38.3 ± 0.44	90.2 ± 0.82

1). Nonetheless, wool produced per kg of body weight at Canarvon Experimental Station was twice as high in Merinos compared to Afrinos.

Correlations between BWa and CFWa were -0.14, 0.12 and 0.22 for AC, MC and MG respectively. The positive correlations obtained in both Merino flocks are in accordance with most genetic correlations reported for Merinos (Fogarty, 1995). Within flocks, these positive correlations may be mediated by increased voluntary feed intake, associated with better adapted animals which will result in increased 18 month body weight and wool growth. The significance of the negative correlation observed in Afrino sheep is unknown.

The relationships between EP and BW within flocks are depicted in Figure 1, whereas relationships between EP and CFW as well as EP and WPP are shown in Figures 2 and 3 respectively. Each data point in these figures represents the mean of the respective traits for each group of 50 ewes.

The regression coefficients of these relationships are given in Table 2.

Within flocks, EP was directly related to BWa (Table 2; Figure 1), a phenomenon similar to the one observed among flocks. This result is in accordance with numerous reports in sheep (Cloete & Olivier, 1995; Fogarty, 1995) which revealed positive genetic and phenotypic correlations between body weight and reproduction rate. Neither the intercepts, nor the slopes of the regression of EP on BWa differed among flocks. Thus, EP was directly related to BWa irrespective of breed or environmental conditions.

Owing to the fact that both CFWa and EP were positively related to BWa in the Merino flocks, it was expected that EP would also be positively related to CFWa. However, it is evident that EP was unrelated to CFWa (Table 2 and Figure 2). In Merino sheep at least, it implies that individuals with high EP would have a higher body weight, with a relatively lower wool production potential. This can be explained best by examining Figure 4 which illustrates the relationship between BWa and

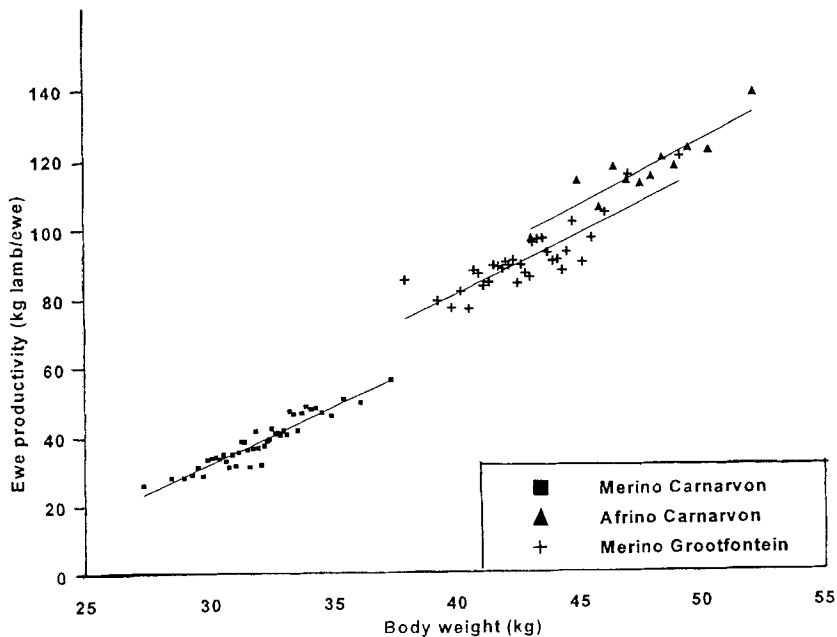


Figure 1 Relationship between body weight (kg) and ewe productivity over three lambing opportunities (kg lamb weaned /ewe) in the Carnarvon Merino and Afrino flocks and in the Grootfontein Merino stud.

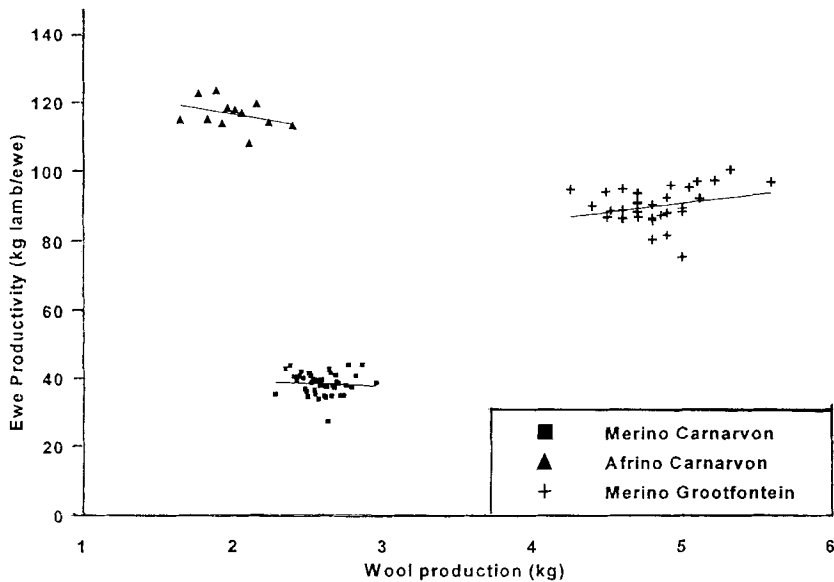


Figure 2 Relationship between clean fleece weight (kg) and ewe productivity over three lambing opportunities (kg lamb weaned / ewe) in the Carnarvon Merino and Afrino flocks and in the Grootfontein Merino stud.

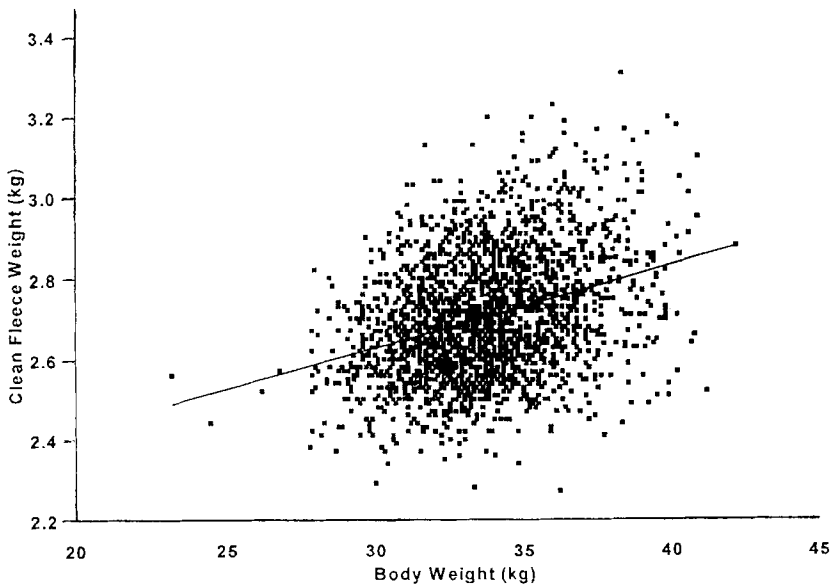


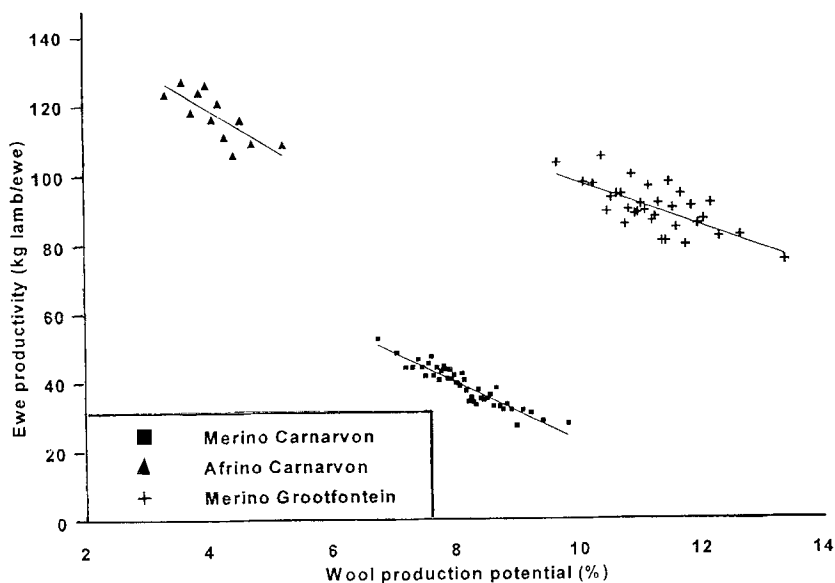
Figure 3 Relationship between body weight (kg) and clean fleece weight (kg) in the Grootfontein Merino stud.

CFWw in the Grootfontein Merino stud.

Individuals with high EP would be those animals with high BW which are below the regression line, i.e. animals which produced less wool per unit of body weight. This view is supported by the

Table 2 Regression coefficients for the regression of BW, CFW and WPP on EP in Merino and Afrino sheep

	a	b	r^2	p
Afrino Carnarvon				
BW	-57.2	3.63	0.830	0.0001
CFW	131.4	-7.28	0.125	0.2598
WPP	162.4	-10.84	0.599	0.0031
Merino Carnarvon				
BW	-70.0	3.29	0.885	0.0001
CFW	41.8	-1.36	0.003	0.7057
WPP	108.4	-8.60	0.872	0.0001
Merino Grootfontein				
BW	-57.9	3.47	0.740	0.0001
CFW	65.2	5.22	0.072	0.1315
WPP	160.1	-6.23	0.497	0.0001

**Figure 4** Relationship between wool production potential (%) and ewe productivity over three lambing opportunities (kg lamb weaned /ewe) in the Carnarvon Merino and Afrino flocks and in the Grootfontein Merino stud.

results presented in Table 2 and Figure 3 which revealed negative relationships between WPP and EP in all three flocks. This observation is in accordance with the differences observed between the two flocks at Carnarvon, as well as results of a study in which five genotypes of woolled sheep were used (Herselman *et al.*, 1993).

Discussion

It is noteworthy that the Angora goat, which is one of the highest fibre-producing small stock breeds, is very susceptible to adverse environmental conditions. Most of the specific problems in the Angora goat are somehow related to its inability to maintain blood glucose levels under stressful conditions (Wentzel *et al.*, 1974; Wentzel *et al.*, 1976; Wentzel *et al.*, 1979; Wentzel, 1987). Most of these problems are resolved by provision of supplementary feeding in the form of grain (starch) which serves as precursor for blood glucose via propionic acid production in the rumen. It may thus be argued that the Angora goat is maladapted to its traditional environment where these problems are experienced. Similarly, from experience in the Karoo region it is known that woolled sheep, especially Merino sheep, are in general more susceptible to cold stress and have a higher incidence of reproduction problems and display lower growth rates than most other breeds when kept in semi-desert environments.

In respect of breeding strategies for woolled sheep, the findings of this study do not suggest selection for decreased fibre production *per se*. On the other hand, the economic reality of increased EP associated with decreased fibre production potential cannot be disregarded. In woolled sheep, kept in sub-optimum environments such as the semi-desert regions of South Africa, the income from mutton and wool is of equal importance and therefore the issue of hardiness becomes of greater importance. For example, certain breeds in South Africa, such as the Dohne Merino, with a lower wool production function, were specifically developed to produce in environments where the Merino was apparently maladapted. It is therefore doubtful whether selection in these breeds should be focused on increased fibre production, especially as genotypes with a higher wool production function already exist.

It would be incorrect to conclude that problems regarding adaptation to adverse environmental conditions exist only in woolled sheep and that mutton sheep are presumably hardy. The results of this study indicate that in woolled sheep, there is a greater danger of selecting less hardy animals for breeding purposes owing to the economic importance of wool production. Any selection performed under optimum nutritional conditions, obviously, does not take hardiness into account. In mutton sheep this issue may be of even greater economic importance as income, realised by these animals, depends solely on reproduction and growth performance. However, a method has still to be developed to evaluate hardiness of individual animals irrespective of environmental conditions in which such animals are kept. To achieve this, more research on the underlying physiological mechanisms which influence hardiness, and the response of these mechanisms to selection, is needed. With the limited information available at present, it may be advisable to perform selection under conditions similar to those which prevail in practice.

Conclusion

It is concluded that any selection program with the net result of increased WPP will have a detrimental effect on ewe productivity irrespective of breed and environment. The concept of adaptation to adverse environmental conditions needs to be duly considered in all sheep, in particular those with a fibre production function. The practice of providing optimum nutritional conditions to stud animals should be discouraged where the progeny is to produce under less favourable conditions. Finally, the inverse relationship between wool production potential and hardiness irrespective of environment, as displayed by the present results, calls for urgent revision of selection objectives presently in use for fibre-producing animals.

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