THE COMBINATION OF RECORDS OF PRODUCTION, REPRODUCTION AND SUBJECTIVE TRAITS IN A PROVISIONAL SELECTION INDEX

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INTRODUCTION

The indices and estimated breeding values derived for different production and reproduction traits form the basis of the National Small Stock Improvement Scheme (NSSIS) in South Africa. The net result of selection is an increase in production and reproduction or income per head as set out by Olivier (1999). It has to be stressed that specific production traits may contribute positively as well as negatively towards farm income. Increased body weight, for example, has a direct positive influence on income through higher carcass weight of culled ewes. It also has an indirect positive influence on income as the faster-growing progeny of such ewes can be marketed earlier. Having the lambs on the farm for a shorter period allows the farmer to keep more ewes on the same area of land. However, increased body weight of the breeding ewe flock also has an indirect negative influence on income, as heavier animals require more food. Fewer of the larger animals can therefore be kept on the same area of land when compared to smaller animals. Increased weaning percentage directly increases income as a result of more lambs available for marketing but it also has an indirect negative influence on income because a higher number of lambs require more grazing which in turn dictate that fewer ewes can be kept (Herselman, 2004). Increased clean fleece weight has a direct positive influence on income through increasing the quantity of product while a decreased fibre diameter has a positive influence on income through a price premium for finer wool (Herselman & Olivier, 2010).

It has been shown that marked responses in different production traits of sheep can be achieved through selection based on BLUP of breeding values in Afrino sheep (Snyman, 2009) and also in Merino sheep (Olivier, 1989; Cloete et al. 2004; Olivier, 2013). Selection for improved production and reproduction can be supported with the establishment of an index that is a combination of the production and reproduction traits and their respective economic contribution. Herselman & Olivier (2010) derived such a model for Merino sheep that combined a five year rolling average of the wool and meat prices and the estimated breeding values of the production and reproduction traits. The objectives of this study were to determine the economic contribution of the production and reproduction traits under different selection scenarios and compare the relative economic value encompassed in the present selection index prescribed by Merino SA as a selection aid for stud breeders and commercial farmers in identifying the best animals for their stud or flock.

MATERIALS AND METHODS

This current selection index used by participants of the Merinoplan (Improvement plan of Merino SA) was developed by Herselman (2004) and refined by Herselman & Olivier (2010). The aim of this index was to calculate an estimated breeding value (EBV) for profitability or relative economic value (REV) by incorporating estimated breeding values for economically important traits and the wool and mutton prices of the last five years. During 2013 this selection index was again refined and changes were made to ensure that the index represents the current wool and mutton markets. The body weight values, as well as wool and mutton prices used previously to create the simulation database with SM2000 (Herselman, 2002a; b) were changed as summarised in Table 1. The values for clean fleece weight and lambing percentage were kept the same.

Table 1. Body weight, clean fleece weight, lambing percentage and wool and mutton prices used to create the simulation database before 2013 and thereafter

	Body weight (kg		**Clean fleece weight (kg)**	**Lambing %**	**Wool Price (R)**		**Mutton price (R)**	
	Pre 2013	**2013**			**Pre 2013**	**2013**	**Pre 2013**	**2013**
High	50.0	58.0	4	130	15	0.5 x WP	10	0.5 x MP
Middle	51.5	54.0	3	100	25	WP	15	MP
Lower	53.0	50.0	2	70	35	1.5 x WP	20	1.5 x MP

WP = five year rolling average of the wool price; MP = five year rolling average of the mutton price

The REV equation is recalculated annually in September from the previous five seasons' wool and mutton prices. The prices are updated in September of each year. The average wool price, as well as the average wool prices of good top maker wool at three length and nine micron categories of each wool season, are included in the estimation of the equations and are made available by Cape Wools. The weighted average mutton price for each season (August to July) that is included is calculated from the weekly purchase price of lamb carcasses and the total weight of the carcasses purchased for grades A0 to A6 which is obtained from the Red Meat Abattoir Association. The wool and mutton prices from 1996 to 2013 were used to calculate the equations for each year from 2001 to 2013. The following two REV equations, including (REV (Rep)) or excluding (REV) reproduction, were derived from the model:

$$\text{REV (R/SSU)} = -1044.64 + 3.61\text{BWebv} + 75.04\text{CFWebv} + 0.3\text{SLebv} - 123.26\text{FDebv} + 2.6116(20+\text{FDebv})^2$$

REV (Rep) (R/SSU) = -1040.92 - 0.36BWebv + 74.82CFWebv + 0.3SLebv - 122.82FDebv + $2.6023(20+\text{FDebv})^2$ + 9.27TWWebv

where REV (R/SSU) is the relative economic value expressed in Rand (ZAR) per small stock unit, BWebv is the estimated breeding value for body weight, CFWebv is the estimated breeding value for clean fleece weight, SLebv is the estimated breeding value for staple length, FDebv is the estimated breeding value for fibre diameter and TWWebv is the estimated breeding value for total weight of lamb weaned.

Further quantification of the economical contribution of each trait under different selection scenarios was done with the MTINDEX Excel spreadsheet for the calculation of selection indices (Van der Werf, 2008). Genetic information was combined with economic information to investigate the impact of a limited number of plausible selection strategies, involving a combination of qualitative and quantitative production traits.

The traits that are normally included in selection programs for Merino sheep in South Africa were used for this analysis. These traits included body weight (BW), clean fleece weight (CFW), fibre diameter (FD), staple length (SL) and staple strength (SS) measured at 15 months of age, number of lambs weaned (NLW), wool quality (WQ) and overall body conformation (BC). The economic values of a trait were defined from the wool and meat prices of the 2012-2013 season, as well as the 2000-2001 season. This was done to compare two different wool pricing scenarios, namely substantial price premiums for fibre diameter (2000-2001) and for high wool prices, without an excessive premium for fibre diameter (2012-2013).

The phenotypic standard deviation, prices, and heritabilities of the traits, as well as the genetic and phenotypic correlations, are summarised in Table 2. The phenotypic standard deviations, heritabilities and correlations for and among the respective traits were obtained from Olivier (2013).

Table 2. Heritabilities, genetic and phenotypic correlations, phenotypic standard deviations (SD) and economic weights according to prices in 2000-2001 (EW1) and in 2012-2013 (EW2) (both in ZAR) for the production, reproduction and subjective traits

Trait	**BW**	**CFW**	**FD**	**SL**	**SS**	**NLW**	**WQ**	**BC**
SD	11.69	1.35	1.59	17.16	11.11	44.65	7.72	6.99
EW1	R 19.80	R 417.10	-R 35.00	R 0.50	R 0.50	R 24.00	R 1.80	R 2.00
EW2	R 6.79	R 183.35	R 220.00	R 0.50	R 0.50	R 12.00	R 0.50	R 0.75
Heritabilities (bold on the diagonal), genetic correlations (below) and phenotypic correlations (above)								
BW	**0.49**	0.29	0.21	0.12	0.17	0.05	0.03	0.59
CFW	0.03	**0.55**	0.20	0.34	0.18	-0.06	0.17	0.24
FD	0.30	0.24	**0.63**	0.07	0.30	0.05	-0.32	0.17

SL	0.10	0.48	0.08	**0.41**	0.12	-0.04	0.17	0.26
SS	0.20	0.27	0.51	0.06	**0.26**	0.07	0.06	0.22
NLW	0.31	-0.23	0.56	0.16	0.19	**0.02**	-0.05	0.07
WQ	-0.01	0.28	-0.45	0.30	0.13	-0.21	**0.54**	0.72
BC	0.82	0.06	0.27	0.45	0.35	0.35	0.93	**0.48**

Trait definitions: BW – body weight, CFW – clean fleece weight, FD – fibre diameter, SL – staple length, SS – staple strength, NLW – number of lambs weaned, WQ – wool quality, BC – body conformation

The different selection scenarios that were considered were as follows:

1. All the information on all traits was utilised,
2. Only own body weight records were used from available replacements,
3. All body weight records from animals were used,
4. All body weight and fibre diameter records from animals were used,
5. Only own fibre diameter records from replacement animals were used,
6. All fibre diameter records from all animals were used,
7. All body weight, clean fleece weight and fibre diameter records from animals were used,
8. All number of lambs weaned records from live animals were available (by implication all female relatives in production, as the replacement animal would not have a record of its own),
9. All body weight, clean fleece weight, fibre diameter and number of lambs weaned records from animals were available (the closest scenario to the relative economic values provided by the NSSIS),
10. Only own wool quality and body conformation scores from live replacement animals were available,
11. All wool quality and body conformation scores from live animals were available.

RESULTS AND DISCUSSION

Figures 1 and 2 depict the effect of wool and mutton prices on the components that influence the relative economic value with or without reproduction for Merino sheep in South Africa. It is evident from the results of this study that there was a marked increase in the average wool and mutton prices from 2010. The contribution on the equation of clean fleece weight and fibre diameter follows the same trend as the wool price in both equations. The increase in the contribution of fleece weight to the profitability was the result of the increase in the wool price and the decrease in the price premium paid for fine wool.

The contribution of staple length in the calculation of the REV and REV (Rep) is very low. In the equation that excludes reproduction, body weight has a very small, but positive contribution compared to a negative contribution in the equation that includes reproduction (Figure 1 & 2). This shift is due to indirect selection for reproduction incorporated in the REV equation. The increase in mutton prices led to a marked increase in the contribution of reproduction on the REV.

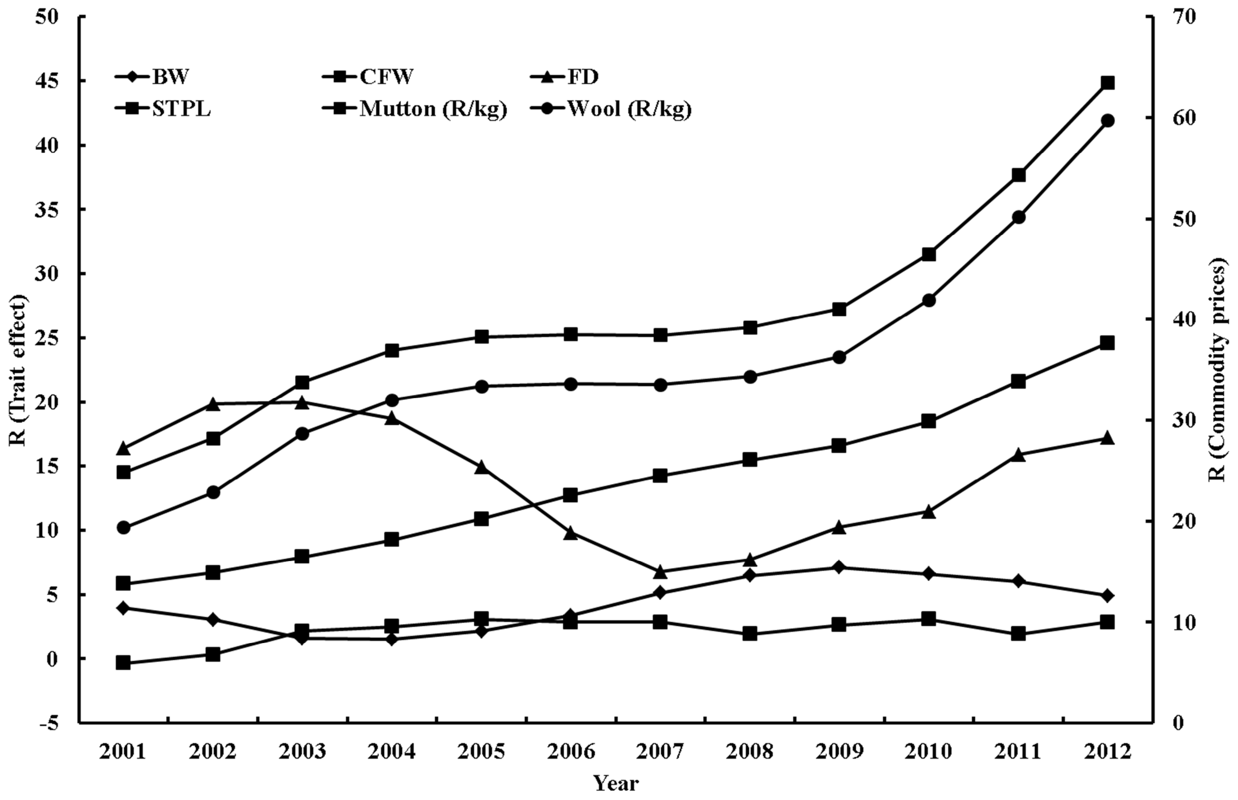

Figure 1. The effect of wool and mutton price on the components of the relative economic value

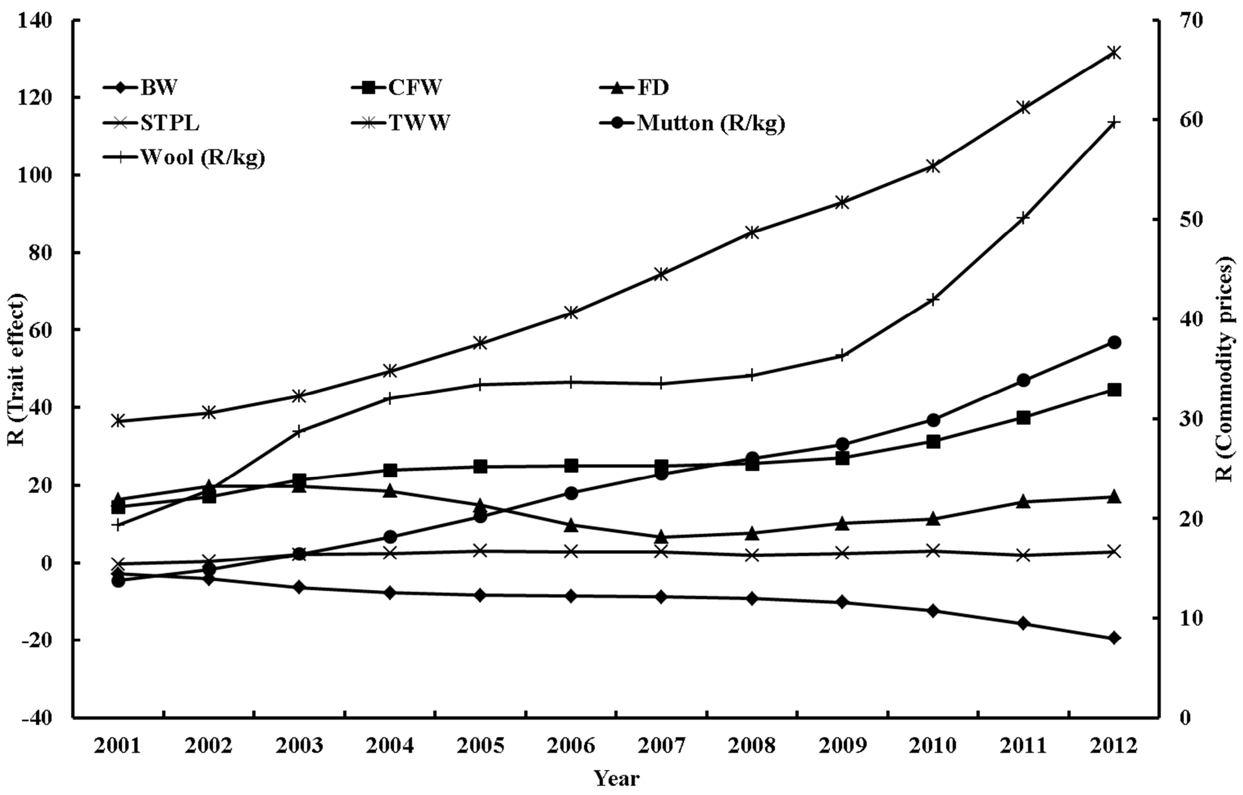

Figure 2. The effect of wool and mutton price on the components of the relative economic value (Reproduction included)

Outcomes from the calculations with the MTINDEX Excel spreadsheet (Van der Werf, 2008) were expressed as responses per generation and were therefore divided by 4 years to get the response per year. The genetic gains expressed in ZAR per year for 2012-2013 are presented in Table 3, while the gains for 2000-2001 are presented in Table 4. The total gains of Scenarios 2 to 11 in both tables were expressed as a percentage of the gain of Scenario 1.

Clean fleece weight had the highest contribution to the monetary gain per year for Scenario 1 using the present price structure (Table 3). This can be expected with the current situation of a very high wool price, without excessive price premiums for fibre diameter. The negative contribution of fibre diameter can be ascribed to the fact that the price premium for a decrease of 1 μm is relatively small, while fibre diameter is also unfavourably correlated with clean fleece weight.

It is evident from Table 3 that the expected gains from Scenarios 7 and 9 that include information on clean fleece weight were similar (>90%) to gains from Scenario 1. Scenario 8 had the lowest genetic gain of all the scenarios, which were approximately 25% of the expected gain from Scenario 1. Selection based only on body weight and/or fibre diameter information (Scenarios 2 to 6) will lead to genetic gains that vary from 47.5% (Scenario 2) to 67.6% (Scenario 4) of Scenario 1. When selection is only based on information of subjective traits in Scenarios 10 and 11 the expected genetic gains amount to 60.3% and 66.9% respectively.

The effect of price premiums for fibre diameter is evident in Table 4, where fibre diameter had the largest contribution to genetic gains per year in all 11 scenarios. NLW had the second highest contribution in all the scenarios, even if no selection was done for this trait. This can be attributed to the correlations among these traits. Scenarios 4 to 7 and Scenario 9 will result in almost similar genetic gains (approximately 90%) when compared to Scenario 1 under the 2000-2001 pricing regime.

These calculated selection responses from the 2000-2001 and 2012-2013 wool and meat prices corresponded with the relative economic values estimated for Merino sheep in the early 2000's and currently.

The antagonistic relationships between traits of economic importance (Olivier, 2013) can be detrimental if these relationships are ignored. Olivier et al. (2013) stated that replacement animal selection should not be done blindly. The implementation of a selection index based on current monetary values will aid breeders and producers in the selection of replacement animals. Furthermore, it is important to include all the traits of economic importance either as a selection objective or as a trait to be monitored for unwanted change (Olivier et al., 2014). Caution must therefore be taken in compiling the selection objective to ensure that sheep enterprises are profitable.

Table 3. Output from MTINDEX summarising the genetic gain in monetary terms for each trait under the 11 different scenarios using the 2012-2013 price structure

Trait	**Monetary gain per year (ZAR) according to different scenarios**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	All traits[1]	**BW[2]**	**BW[1]**	**BW & FD[1]**	**FD[2]**	**FD[1]**	**BW, CFW & FD[1]**	**NLW[1]**	**BW, CFW, FD & NLW[1]**	**WQ & BC[2]**	**WQ & BC[1]**
BW	16.03	28.19	30.92	25.64	10.23	10.72	15.13	4.87	14.93	24.35	27.22
CFW	58.91	0.45	0.49	10.32	14.38	15.07	64.66	-9.39	62.28	5.05	4.79
FD	-5.56	-2.51	-2.75	-7.98	-9.09	-9.52	-5.87	-2.40	-5.96	-2.76	-3.24
SL	0.65	0.10	0.10	0.12	0.09	0.09	0.42	0.08	0.44	0.33	0.35
SS	0.24	0.49	0.11	0.26	0.28	0.29	0.26	0.05	0.25	0.16	0.17
NLW	23.48	17.23	18.9	35.50	34.71	36.36	11.24	30.98	16.7	28.14	32.12
WQ	0.33	0.03	0.04	-0.49	-0.73	-0.77	0.00	-0.20	-0.01	0.57	0.54
BC	1.21	1.28	1.40	1.01	0.25	0.26	0.80	0.32	0.83	1.65	1.78
Total (R)	95.28	45.26	49.21	64.38	50.11	52.50	86.64	24.31	89.47	57.48	63.72
Total (%)[3]	100.00	47.50	51.65	67.57	52.59	55.10	90.93	25.51	93.90	60.33	66.88
Accuracy	0.74	0.35	0.38	0.50	0.39	0.41	0.67	0.19	0.70	0.45	0.50

[1] – all pedigree information and records; [2] – only own record; [3] – expressed as a percentage from scenario 1; BW – body weight at 15 months of age; FD – fibre diameter at 15 months of age; CFW – clean fleece weight; SL – staple length; SS – staple strength; NLW – number of lambs weaned; WQ – wool quality; BC – body conformation; Total – total response

Table 4. Output from MTINDEX summarising the genetic gain in monetary terms for each trait under the 11 different scenarios using the 2000-2001 price structure

Trait	**Monetary gain per year (ZAR) according to different scenarios**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	All traits[1]	**BW[2]**	**BW[1]**	**BW & FD[1]**	**FD[2]**	**FD[1]**	**BW, CFW & FD[1]**	**NLW[1]**	**BW, CFW, FD & NLW[1]**	**WQ & BC[2]**	**WQ & BC[1]**
BW	5.01	9.67	10.6	5.45	3.51	3.68	4.75	1.67	4.73	8.01	9.13
CFW	15.06	0.20	0.22	6.24	6.32	6.62	15.76	-4.13	15.33	-1.53	-1.40
FD	56.73	15.76	17.28	59.29	57.14	59.87	57.10	15.10	57.40	26.31	29.07
SL	0.35	0.10	0.10	0.11	0.09	0.09	0.23	0.08	0.25	0.17	0.20
SS	0.30	0.10	0.11	0.29	0.28	0.29	0.31	0.05	0.31	0.12	0.14
NLW	18.9	8.61	9.45	18.8	17.35	18.18	15.22	15.49	17.18	16.67	18.69
WQ	-0.12	0.01	0.01	-0.20	-0.20	-0.21	-0.15	-0.06	-0.15	-0.12	-0.41
BC	0.26	0.48	0.52	0.19	0.09	0.10	0.19	0.12	0.20	0.34	1.09
Total (R)	96.49	34.92	38.30	90.17	84.58	88.61	93.40	28.33	95.26	49.95	56.51
Total (%)[3]	100.00	36.19	39.69	93.45	87.66	91.83	96.80	29.36	98.73	51.77	58.57
Accuracy	0.83	0.30	0.33	0.77	0.73	0.76	0.80	0.24	0.82	0.43	0.48

[1] – all pedigree information and records; [2] – only own record; [3] – expressed as a percentage from scenario 1; BW – body weight at 15 months of age; FD – fibre diameter at 15 months of age; CFW – clean fleece weight; SL – staple length; SS – staple strength; NLW – number of lambs weaned; WQ – wool quality; BC – body conformation; Total – total response

CONCLUSIONS

It can be concluded from the results of this study that the estimated breeding value for Profit (R/SSU) used by Merino SA will be a beneficial selection tool for wool farmers in South Africa to identify future breeding stock that will have a positive effect on the profitability of their farming enterprise. However, it is important that selection objectives for individual traits are used as individual culling levels in combination with the REV when breeding sires and dams are selected. This is due to the fact that different combinations of the estimated breeding values for the individual traits can lead to the same REV.

It is important that care should be taken when replacement animals are selected under the current selection regime as fleece weight is presently overemphasised due to the favourable wool price. This could have a detrimental effect on the reproduction potential of the enterprise due to generally unfavourable genetic correlations between reproduction traits and fleece weight.

A large proportion of Merino sheep in South Africa is still selected on subjective traits, therefore hampering the genetic progress of the Merino breed. This practice may have a negative effect on the contribution that the Merino breed can have on food security and rural wealth creation in South Africa. It is therefore imperative that Merino ram breeders in South Africa should start to select replacement animals on production and reproduction performance and to make these types of animals available to the industry for commercial production.

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