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ACCOUNTING FOR THE EFFECT OF INCREASING TWINNING RATE IN EWE WOOL PRODUCTION IN THE BREEDING OBJECTIVE FOR MERINO SHEEP

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SUMMARY
Two methods of accounting for a reduction in ewe fleece weight (aCFW) due to increased twinning are compared: adjusting the economic value of twinning rate for the reduction in aCFW, and creating a new trait (twinning effect on ewe fleece weight, TE_aCFW). A situation in which the reduction in aCFW is ignored is also examined. The two methods produced identical results, as expected, given the assumptions made. Ignoring the reduction in aCFW had a negligible effect on genetic gain. The likely advantages of creating the new trait TE_aCFW are discussed.
Keywords: Breeding objective, Merino sheep, twinning rate, fleece weight.

INTRODUCTION
Ewe lambing status (e.g. dry, single bearing, twin bearing) affects fleece weight (Turner and Young 1969). Phenotypic and genetic parameters for wool traits in breeding ewes are usually estimated adjusting for lambing status in some way (e.g. parameters used in RAMPOWER, Atkins, pers. comm., or compiled by Ponzoni *et al.* 2000). When such parameters are used in predictions of genetic gain any reduction in ewe fleece weight due to an increase in twinning rate is not accounted for by the phenotypic and genetic variance-covariance matrices (James 1986). In this paper we compare two methods of accounting for a reduction in fleece weight due to increased twinning, namely, adjusting the economic value of twinning rate for the likely reduction in ewe fleece weight, or creating a new trait (twinning effect on ewe fleece weight). Both methods are compared with a situation in which the reduction in fleece weight due to increased twinning is ignored altogether.

MATERIALS AND METHODS
We defined two simple breeding objectives which included hogget clean fleece weight (hCFW), adult ewe clean fleece weight (aCFW), hogget average fibre diameter (hFD), adult ewe average fibre diameter (aFD), twinning rate (T), hogget live weight (hLW) and adult ewe live weight (aLW). The economic value for each trait was calculated using the prices and costs specified in the Appendix, and also after doubling sheep meat prices, using the methodology and flock structure described by Ponzoni (1988). The economic value of T was calculated ignoring any twinning effect on aCFW (Objective 'No TE'), and discounting it for the reduction in aCFW among ewes with twins (Objective 'Disc. TE'). A third breeding objective included an additional trait, which we called 'twinning effect on aCFW' (TE_aCFW) and we defined as:

$$TE\_aCFW = -d\ (T)$$

where d is the difference in clean fleece weight between ewes with twins and ewes with singles and T is the proportion of ewes with twins. We assumed d was a constant (0.35kg) in the flock, based on data from SARDI's experimental sheep. Note that estimates of d from normally lambing ewes could be biased because ewes with single or twin lambs are not a random sample due to correlations between traits. There are no published phenotypic and genetic parameters for TE_aCFW in the literature, but they can be derived from the parameters for other traits. The variance of TE_aCFW is:

$$\text{var (TE\_aCFW)} = d^2 \text{ (var T)}$$

whereas the covariance between TE_aCFW and any other trait Y may be calculated as:

$$\text{cov (TE\_aCFW, Y)} = -d \text{ [cov (T, Y)]}$$

From the above it can be seen that TE_aCFW has the same heritability as T, and that its correlation with any other trait is the same as for T, but of opposite sign. Table 1 shows the assumed phenotypic and genetic parameters. Values were taken from those used in RAMPOWER (Atkins, personal communication), and from the estimates compiled by Ponzoni *et al.* (2000).

Table 1. Phenotypic and genetic parameters (phenotypic correlations above, genetic correlations below the diagonal)

Trait	hCFW kg	ACFW kg	hFD μ	aFD μ	T Proport.	TE_CFW kg	hLW kg	aLW kg
Mean	4.4	5.0	21	23	0.35	-0.122	50	60
h^2	0.40	0.45	0.60	0.60	0.15	0.15	0.40	0.40
σ^2_P	0.548	0.722	3.61	4.41	0.228	0.0279	30.6	46.2
hCFW		0.70	0.25	0.20	0.1	-0.1	0.30	0.25
aCFW	0.80		0.20	0.30	0.1	-0.1	0.25	0.30
hFD	0.20	0.30		0.80	0.1	-0.1	0.20	0.20
aFD	0.20	0.30	0.90		0.1	-0.1	0.20	0.20
T	0.1	0.1	0.1	0.1		-1.0	0.20	0.30
TE_CFW	-0.1	-0.1	-0.1	-0.1	-0.1		-0.20	-0.30
hLW	0.25	0.20	0.15	0.15	0.20	-0.20		0.75
aLW	0.20	0.25	0.15	0.15	0.30	-0.30	0.95	

We assumed that ten percent of the ewes did not lamb each year, and that there was no genetic variation for the trait 'proportion of ewes lambing', consistent with research findings indicating a very low heritability for the trait (Purvis and Hillard 1997). Improvement in reproductive rate would come about from an increase in the proportion of twins produced by ewes that lamb (90 per cent). We calculated genetic gain per generation for individual traits and overall gain in economic units using an index which included own performance for hCFW, hFD and hLW, and information on the dam (3 records), on the maternal and paternal grand-dams (5 records), on ten half-sisters of the dam (3 records), and on ten half-sisters of the sire (3 records) for T (assumed repeatability for T was 0.2).

RESULTS AND DISCUSSION

Table 2 shows the economic value of each trait. In the case of T, the economic value was smaller when it was discounted for the likely reduction in aCFW among twinning ewes than when it was not (e.g. Objective Disc. TE *vs* Objective No TE). Note that the economic value of TE_aCFW is the same as for aCFW, but multiplied by a factor that accounts only 90 per cent of the ewes lambing.

Table 2. Economic values ($ per ewe lifetime) calculated for clean fleece weight, fibre diameter and live weight (hogget and adult), twinning rate and twinning effect on adult clean fleece weight

Objective	hCFW	ACFW	hFD	AFD	T	TE_CFW	hLW	aLW
No TE	15.2	17.0	-5.11	-7.84	71.6	…	0.35	-0.60
Disc. TE	15.2	17.0	-5.11	-7.84	66.2	…	0.35	-0.60
TE_aCFW	15.2	17.0	-5.11	-7.84	71.6	15.3	0.35	-0.60
Double Sheep meat prices								
No TE	15.2	17.0	-5.11	-7.84	165.6	…	1.41	-0.22
Disc. TE	15.2	17.0	-5.11	-7.84	160.3	…	1.41	-0.22
TE_aCFW	15.2	17.0	-5.11	-7.84	165.6	15.3	1.41	-0.22

Table 3 shows the genetic gain per generation in the traits in the breeding objective as well as the overall gain in economic units following one round of selection on the index with a selection intensity equal to one. There was little difference in genetic gain in individual traits or in the overall economic gain among the three objectives (No TE, Disc. TE and TE_aCFW). Ignoring the twinning effect on aCFW overestimated σ_I by one per cent or less. Doubling sheep meat prices more than doubled the gain in T, hLW and aLW and the loss due to TE_CFW, slowed down the reduction in FD, but had little effect on CFW.

Table 3. Genetic gain per generation in the traits in the breeding objective and overall gain in economic units

Objective	hCFW kg	ACFW kg	hFD μ	aFD μ	T Prop.	TE_CFW kg	hLW kg	aLW kg	σ_I $
No TE	0.147	0.092	-0.82	-0.80	0.023	-0.008	0.203	0.214	15.74
Disc. TE	0.146	0.091	-0.83	-0.81	0.021	-0.007	0.181	0.184	15.62
TE_aCFW	0.146	0.091	-0.83	-0.81	0.021	-0.007	0.182	0.184	15.62
No TE	0.142	0.103	-0.54	-0.51	0.052	-0.018	0.823	1.018	20.29
Disc. TE	0.143	0.103	-0.55	-0.53	0.051	-0.018	0.817	1.008	20.01
TE_aCFW	0.143	0.103	-0.55	-0.53	0.051	-0.018	0.817	1.008	20.01

We conclude that ignoring the twinning effect on ewe fleece weights is unlikely to over-estimate the economic worth of genetic gain or alter genetic change in individual traits. It is better in principle, however, to allow for such an effect, given that we know it exists. Discounting the economic value of

T and creating a new trait (TE_aCFW) produced identical results, as is to be expected, but the latter approach is more elegant and explicitly shows the magnitude of the loss due to an increase in the twinning rate. The approach introduced here can be extended to other traits that could be affected by T, such as staple strength. Then the expected changes in all such traits would be made clear instead of being hidden in the value of twinning.

Note that we assumed the difference (d) in aCFW between ewes with singles and ewes with twins was a constant, so that all the variation in the new trait (TE_aCFW) was associated with variation in T. In principle, there could be variation in TE_aCFW that was independent of variation in T. If that were the case the method of discounting the economic value of T would be inappropriate, whereas creating a new trait would be a useful alternative. Developments in reproductive technology could result in the generation of large numbers of relatives normally uncommon in sheep (e.g. identical twins), and that may enable estimation of genetic variation for TE_aCFW or similarly defined traits.

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APPENDIX

Product prices	
Clean wool, hoggets ($ per kg)	6.50
Clean wool, ewes ($ per kg)	5.60
Fibre diameter [A]	0.45
Surplus hoggets ($ per head)	30.00
Cull for age ewes ($ per head)	25.00

[A] Price change ($) of 1.0 kg of clean wool per micron change in fibre diameter

Costs	
Wool harvesting and marketing ($ per head)	3.50
Wool harvesting and marketing ($ per kg clean)	1.20
Feed for surplus offspring ($ per head)	18.00
Cost of husbandry and marketing surplus offspring ($ per head)	5.00
Cost of feeding heavier offspring ($ per additional kg of live weight)	0.25
Cost of feeding heavier ewes ($ per additional kg of live weight)	0.25