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Trait economic weights for genetic improvement with SIL

P.R. AMER

AgResearch Invermay, Private Bag 50034, Mosgiel, New Zealand

ABSTRACT

This paper outlines the construction of industry selection indexes for the SIL sheep genetic evaluation process. Traits of direct economic importance in New Zealand sheep production form goal trait groups with each goal trait assigned an economic weight for use in selection indexes. Goal trait group indexes are calculated as the sum of breeding values for each goal trait within the relevant group after multiplication by the relevant economic weight. Three overall indexes can also be calculated by combining goal trait group indexes. The three overall indexes include a Dual Purpose (DP) index, a Terminal Sire (TS) index and a Fine Wool (FW) index. Flexibility is offered to users through the ability to choose overall and goal trait group indexes presented in their results, and the ability to add new indexes to the system.

Keywords: economic weights; sheep; genetic improvement; lamb production; wool production.

INTRODUCTION

Sheep production systems in New Zealand are diverse, and consequently, a wide range of traits can be used to both describe the relative economic profitability of a breeding animal, and for recording in sheep improvement programmes. When assessing the genetic merit of an individual sheep, there is usually a plethora of information available on the individual for a number of traits, as well as across all relatives and contemporaries of the individual. Genetic evaluation procedures (Newman *et al*., 2000) apply statistical methods to recorded information to produce best estimates of breeding values for economically important traits. In this way, selection decisions by sheep breeders and their clients can make efficient use of pedigree and performance records. Further, collation of breeding value information for individual traits is achieved by computing selection indexes which encompass all, or sub groups, of economically important traits. In a selection index, economic weighting factors are used to assign economic emphasis to alternative traits.

Alternatives to index selection such as the application of independent culling thresholds are typically cumbersome to operate, and often result in very inefficient use of the information made available through genetic evaluation. Selection indexes, and the calculation of economic weights, are therefore critical features of a practical, user friendly, genetic evaluation system. The objective of this paper is to describe how they have been developed and applied in the SIL genetic improvement system.

SELECTION INDEX STRUCTURES

For multi-trait genetic prediction situations, it is theoretically optimal, but often impractical, to include all selection criteria in a single genetic analysis. Within the SIL genetic engine, economic traits are divided into goal trait groups (e.g. growth, meat, reproduction, wool, survival and disease), with relevant subsets of recorded traits used for their prediction. Indexes calculated for goal trait groups (see below) are used to provide detailed insight into the merit of individual animals for specific trait groups. When selection criteria corresponding to a large range of goal traits have been recorded and genetically evaluated to produce breeding values, sub-indexes offer the convenience of correctly combining the information across many traits. At the same time, they preserve some information about an individual selection candidates strengths and weaknesses across broad groups of sheep production traits. Sub-index units are dollar per ewe lambing, and taking the Dual Purpose index as an example, can be obtained for growth, meat, survival, reproduction, wool and disease goal trait groups, provided there has been sufficient information recorded.

The goal trait groups have been defined so as to be independent, to enable indexes corresponding to each group to be added together, to produce an overall index. Where possible, calculation of goal trait group indexes is independent to whether or not other goal trait groups are being evaluated. However, because of some overlap among economic traits in the growth and meat goal trait group indexes, calculation of their indexes depends on whether or not the other goal trait group is being evaluated at the same time. This is handled within the genetic evaluation process and preserves the additive interpretation of goal trait group indexes.

Addition of goal trait group indexes to obtain overall indexes provides a summary of the overall economic breeding merit of animals across all commercially relevant traits. The units of all indexes are in dollar per ewe lambing, with the assumption that one half of an animal's own breeding merit is passed on to its offspring.

WEIGHTINGS FOR ECONOMIC TRAITS

Indexes weight breeding values for economically important goal traits (e.g. carcass weight, adult fleece weight and number of lambs born), by:

- the economic value of a unit change in the trait, e.g. the value of one kg extra carcass weight is $3.00, and the value of one extra lamb born per ewe lambing is $17.20 after accounting for feed costs and lamb deaths etc.
- the expected timing and frequency of expression of the trait (discounted expressions). e.g. adult ewe traits are expressed later, but more frequently, than ewe hogget traits. In other words for every one expression of an adult ewe trait at lambing, we expect to see .36 expressions of hogget traits.
- the expected proportion of the industry to which the

trait is relevant (industry weighting factor). e.g. weaning weight is more relevant than carcass weight when lambs are sold as stores.

When taken together, the above three components provide an economic weight, which is multiplied by the corresponding goal trait breeding value. These economic weights need to be monitored over time, and fine-tuned, to take into account changes in industry structure, product prices and costs, as well as changes in sheep farming practices. Assignment of economic weights also needs to be focussed on future developments and changes, because of the inherent delays between the time a selection decision is made, and the time at which the genes of a selected individual are expressed in its descendants.

Tables 1, 2 and 3 describe the calculation of economic values for SIL Industry Dual Purpose, Terminal Sire and Fine Wool indexes respectively as products of the goal trait economic value, discounted expressions and industry weighting factor. Details of how these coefficients have been derived can be found in Amer *et al*. (1998) and Amer (1998; 1999).

APPLICATIONS

Selection indexes are an important component of effective selection in sheep improvement programmes, because of the large number of breeding values for economically important traits predicted from selection criteria. Industry indexes available in the past (e.g., Binnie *et al*., 1992; McEwan, 1994) have served a useful purpose, but were sometimes criticised as being inappropriate to specific production systems or environments. They also tended to address a narrower range of traits, sometimes focussing on selection criteria, rather than on economically important goal traits.

The indexes described in this paper focus on economically important (goal) traits, which means that breeding values must be predicted for goal traits, rather than just for the recorded traits making up the selection criteria. This requires a change of focus and interpretation by some sheep breeders using the system. In particular, it requires that they have confidence in the system to properly account for relationships between recorded traits, and goal traits not directly recorded. Such an approach is becoming increasingly common in animal evaluation systems, and is well founded in selection index theory. A principal advantage from focussing indexes on goal traits is that it facilitates the reporting of sub-indexes (such as the goal trait group indexes described here). These sub-indexes constitute a compromise between comparing selection candidates using a single index (minimum information provided) versus comparing them across all available estimated breeding values (maximum information provided). This approach offers users some flexibility, without burdening them with excessive numbers of individual trait breeding values. Thus, SIL users have the option to obtain genetic evaluation reports with breeding value information summarised in a range of different ways.

TABLE 1: Calculations of economic weights for the SIL Industry Dual Purpose Index

Goal trait group	Goal trait	Economic value[1]	Discounted expressions[2]	Industry weighting factor[3]	Economic weight[4]
DP Growth	Carcass weight, kg	$3.00	0.88	0.4	$1.06
	WWT direct, kg	$1.35	0.90	0.3	$0.36
	WWT maternal, kg	$1.35	1.80	0.3	$0.72
	Ewe weight – feed, kg	$-0.14	1.00	1.0	$-0.14
	Ewe weight – cull, kg	$0.19	0.23	1.0	$0.04
DP Meat	Lean, kg	$6.00	0.88	0.3	$1.58
	Fat, kg	$-5.00	0.88	0.3	$-1.32
DP Survival	Lamb survival prop.	$28	1.20	1.0	$34
DP Reproduction	Number of lambs born	$17.20	1.00	1.0	$17.20
	Hogget fertility	$15.00	0.36	0.3	$1.62
DP Wool	Lamb fleece weight, kg	$3.50	1.20	0.9	$3.78
	Fleece weight 12, kg	$3.50	0.36	1.0	$1.26
	Adult fleece weight kg	$3.50	1.00	1.0	$3.50
DP Disease[5]	FEC1 %	-	-	-	$0.018
	FEC2 %	-	-	-	$0.018
	Adult FEC %	-	-	-	$0.037

[1] Economic values expressed as dollar per lambing for ewe traits, dollar per lamb born for lamb survival, dollar per lamb slaughtered for other lamb traits and dollar per female hogget for hogget traits.
[2] Based on calculations of discounted genetic expressions. Assumptions -average lambs weaned per ewe mated = 1.20, planning horizon = 10 years, discount rate = 7%, ram use = 3 years, ewes mated per ram = 90 and age at first lambing = 2 years and maximum ewe age = 5 years.
[3] Industry weighting factors used to balance out different industry production scenarios. On an industry basis, 30% of lambs are assumed to be sold as stores where weaning weight is relevant and carcass weight, lean and fat not relevant. Another 30% of lambs are assumed to be sold into a pricing system where fatness is penalised and there is a positive value of lean. The other 40% are assumed to fit a marketing schedule where most emphasis is on carcass weight, with WWT, LEAN and FAT irrelevant. Only 30% of commercial flocks are assumed to practice hogget lambing and 90% of lambs to be shorn.
[4] Economic weights used in the industry dual purpose index are calculated as the product of columns 3, 4 and 5.
[5] Economic values, discounted expressions and industry weighting factors are directly incorporated into economic weights for disease (Faecal Egg Count) traits.

TABLE 2: Calculations of economic weights for the SIL Industry Terminal Sire Index

Goal trait group	Goal trait	Economic value[1]	Discounted expressions[2]	Industry weighting factor[3]	Economic weight[4]
TS Growth	Carcass weight kg	$3.00	0.80	0.4	$0.96
	WWT direct kg	$1.35	0.82	0.3	$0.33
TS Meat	Lean kg	$6.00	0.80	0.3	$1.44
	Fat kg	$-5.00	0.80	0.3	$-1.20
TS Survival	Lamb survival prop.	$28	1.00	1.0	$28

[1] Economic values expressed per lamb born for lamb survival and per lamb slaughtered for other lamb traits.
[2] Based on calculations of discounted genetic expressions. Assumptions - planning horizon = 10 years, discount rate = 7%.
[3] Industry weighting factors used to balance out different industry production scenarios. On an industry basis, 30% of lambs are assumed to be sold as stores where weaning weight is relevant and carcass weight, lean and fat not relevant. Another 30% of lambs are assumed to be sold into a pricing system where fatness is penalized and there is a positive value of lean. The other 40% are assumed to fit a marketing schedule where most emphasis is on carcass weight, with weaning weight, and proportions of lean and fat irrelevant.
[4] Economic weights calculated as the product of columns 3, 4 and 5.

TABLE 3: Calculations of economic weights for the SIL Industry Fine Wool Index

Goal trait group	Objective trait	Economic value[1]	Discounted expressions[2]	Industry weighting factor[3]	Economic weight[4]
FW_Base-Wool	Lamb FW (Greasy)	$5.40	0.9	0	0
	FW12 kg (Greasy)	$5.40	0.72	1.0	$3.89
	Adult FW kg (Greasy)	$5.40	1.80	1.0	$9.72
	Mean fibre diameter	$-7.87	2.52	1.0	-$19.80
FW_Wool-Chars	Not yet developed				
FW_Growth	Carcass weight kg	$3.00	0.19	0.35	$0.20
	WWT direct kg	$1.35	0.20	0.65	$0.18
	WWT maternal kg	$1.35	0.40	0.65	$0.35
	Adult weight - feed kg	$-0.14	1.80	1.0	-$0.25
	Adult weight - cull kg	$0.17	0.70	1.0	$0.12
FW_Survival	Lamb survival prop.	$25	0.9	1.0	$23
FW_Reproduct.	NLB	$12.00	1.00	1.0	$12.00
	HF	$7.00	0.30	0	0
FW_Disease[5]	FEC1 %	-	-	-	$0.018
	FEC2 %	-	-	-	$0.018
	Adult FEC %	-	-	-	$0.037

[1] Economic values expressed per lambing for ewe traits, per adult (ewes and wethers) for adult traits, per lamb born for lamb survival, per lamb slaughtered for other lamb traits and per hogget (both male/wether and female) for hogget traits.
[2] Expressed relative to 1 ewe lambing trait. Multiply by .66 to express per adult.
[3] Industry weighting factors used to balance out different industry production scenarios. On an industry basis, 65% of lambs of fine-wool breeds are assumed to be sold as stores where weaning weight is relevant and carcass weight not relevant. The other 35% are assumed to fit a marketing schedule where most emphasis is on carcass weight, with weaning weight, and proportions of lean and fat irrelevant. It is assumed that there is no hogget lambing and no lamb shearing.
[4] Economic weights calculated as the product of columns 3, 4 and 5. Economic weights should be multiplied by their estimated breeding values (estimated either directly from BLUP programmes or via partial genetic regression on selection criteria EBVs) to obtain the total index value for each animal.
[5] Economic values, discounted expressions and industry weighting factors are directly incorporated into economic weights for disease traits as for dual purpose breeds.

Additional flexibility is offered to SIL users via the ability to incorporate new indexes into the system. This allows groups of users to create new indexes which are more appropriate to their environment, production system, or expectation of what future prices are likely to be. Some care will be required, to ensure that this facility is not exploited by vested interests, and that the resulting weighting factors are both biologically, and economically credible.

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