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Examination of selection index weights for lamb production

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ABSTRACT

Economic values for lamb production have historically been derived with the assumption that lambs are slaughtered at a constant age. However, Landcorp Farming Limited slaughters lambs when they reach a set carcass weight. After weaning, heavier lambs are given preferential feeding and slaughtered when they reach a predicted carcass weight of 15kg. In this study index weights for weight of fat (FAT) and weight of lean (LEAN) in the carcass are calculated based on the different costs and returns associated with finishing lambs at a set weight. The nonlinear profit function was responsible for a positive index weight being derived for FAT. This result highlights the problems with using FAT and LEAN as selection criteria for lamb production. It is pointed out that FAT and LEAN are not breeding objectives for sheep production, and that it may be possible to use selection criteria better related to the profit function.

Keywords: economic values; lean; fat; sheep; meat; weight.

INTRODUCTION

Selection indices for lamb production have historically been derived with the assumption that lambs are slaughtered at a constant age (eg Simm *et al*. 1987). For a large operation, considerable gains can be made by slaughtering at a specified carcass weight, thus exploiting variation in lamb growth rates, as well as drafting options (Garrick *et al*.1986) to produce an even product.

There are two main advantages of the lamb drafting and differential feeding strategy employed by Landcorp Farming Limited. Firstly, the production system allows potentially over-fat lambs to be identified at weaning and grown at a slower rate. This strategy brings about a lower proportion of lambs grading as over-fat at slaughter. The second advantage is that lambs can be slaughtered over a wider period of time, which both suits direct marketing of chilled products, and provides lambs to control pasture growth on specialised finishing properties in the spring and early summer.

Landcorp directly markets the majority of its lamb meat. As a consequence the lamb grading system, used to develop current industry breeding objectives, does not provide an appropriate framework from which to develop economic values for a Landcorp breeding objective. However, in the absence of a formally defined profit function and breeding objective, Landcorp has pursued a widely reviewed industry selection index (Waldron *et al*. 1991; Binnie *et al*. 1997).

Index weights for weight of fat (FAT) and weight of lean meat (LEAN) in the carcass, developed from the lamb grading schedule for lambs slaughtered at a constant age (Waldron *et al*. 1991), have been incorrectly defined as breeding objectives. These traits are not breeding objectives as they do not have intrinsic value of their own. The absence of a formal definition of a breeding objective has led to many authors incorrectly referring to FAT and LEAN as the breeding objective for sheep meat production. It is a change in the proportions of animals falling into more profitable parts of the pricing grid that is the implicit breeding objective in this situation.

In this paper FAT and LEAN are considered as selection criteria for terminal sires, with index weights calculated from a profit function. Implicit in the profit function is the definition of a breeding objective which is: to improve profitability by altering the proportions of lambs in higher quality grades, to improve the efficiency of production by altering the timing of supply of lambs, and to alter the age of lambs slaughtered within each quality grade. The intention is to illustrate how index weights for FAT and LEAN, when derived from a profit function, are highly dependent upon the production system used, and mean levels of production.

MATERIALS AND METHODS

The lamb production system used by Landcorp was approximated by simulation. Lambs were allocated to finish either for:

1. The pre-Christmas new season lamb market (EARLY)
2. The post-Christmas period when feed is not limiting on finishing properties (SUMMER)
3. The winter period when feed is a limited resource (WINTER).

It was assumed that lambs were allocated to finish in these groups based on their weaning weight. On average, lambs were weaned at 23kg, and weaning weight was normally distributed with a standard deviation of 5kg. Lambs were allocated to the three finishing groups as follows: Lambs weighing less than 22kg at weaning were assigned to finish in the WINTER group; Lambs weighing between 22kg and 32kg were allocated to finish in the SUMMER group; Lambs weighing more than 32kg were allocated to finish in the EARLY group. This mimics the system used by the company.

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Landcorp's commercial ewes marked during joining, are pregnancy scanned and drafted on predicted birth rank. Thus it was assumed that lambs finishing in each group had different mean birth dates. Important dates for the three finishing groups are shown in Appendix 1. Likewise the mean daily cost of feeding lambs was assumed to differ depending on the time of slaughter of the lamb. A feed budgeting model was used to calculate feed requirements for lambs and the cost of feed at various times of the year. It was assumed that only four and five-year-old ewes are mated to terminal sires, so this simulation only reflects that sector of the lamb finishing business. In each of the three finishing periods a profit function was produced for the average terminally sired lamb. This profit function incorporated returns to all three operational subunits of the company, namely the breeding, finishing and marketing operations.

Landcorp markets cuts from 15kg lambs in both the frozen and chiller markets, with a different proportion of lambs going to each market at different times of the year. Likewise there are different returns for trimmer (GR>12mm) and prime (GR<12mm) grades of lambs for both the frozen and chilled products. Surprisingly, trimmer lambs return marginally more than prime lambs in the frozen markets, and prime lambs return considerably more than trimmer lambs for the chiller market. Thus, the penalty for producing fat lambs in this simulation was partly dependent on the proportions of lambs sold to chilled or frozen markets. Company records were used to ascertain the proportion of lambs within each finishing period that had excessive fat depths at slaughter.

Separate index weights for LEAN and FAT were calculated within each of the three lamb finishing groups. These index weights were calculated in the following way. Lambs with greater than 12mm of GR (trimmer lambs) were dissected differently to leaner (prime) lambs. Within each finishing group, GR depths were assumed to be normally distributed with different means (Appendix 1), a standard deviation of 2.41 mm. The genetic change in GR per 1kg increase in FAT or LEAN was calculated (as the genetic regression of GR on LEAN and FAT). Thus, the change in proportions of lambs grading into the trimmer category from a genetic increase in FAT or LEAN could be ascertained. Likewise the genetic increase in carcass weight resulting from an increase in FAT or LEAN was derived. The genetic change in GR depth and carcass weight per kg change in FAT or LEAN was then used to calculate the change in profitability of the system which would result from genetic improvement.

From the index-weights derived within each finishing period, weighted annual index weights for LEAN and FAT were calculated and compared to the weights in the currently used index. Additional adjustments were made to the average index weights to account for changes in the proportion of animals in each finishing group due to correlated genetic responses in weaning weight and subsequent changes in profit. The following formula was used to create the average total index weights for FAT and LEAN:

$$AvIWt_j = \Sigma(IWt_{ij} * P_i) + \Sigma(\triangle Prof_k * \triangle Prop_k * b_{(ww,j)})$$

where subscript j denotes FAT or LEAN as selection criteria, subscript i denotes EARLY, SUMMER, or WINTER finishing group, and subscript k denotes a change from EARLY to SUMMER slaughter group (k=1) and from WINTER to SUMMER slaughter group (k=2). $AvIWt_j$ is the average index weight for trait j; IWt_{ij} is the weight for trait j within season i; P_i is the proportion of lambs finished in season i; $\triangle Prof_k$ is the change in profit when a lamb is slaughtered in the EARLY or SUMMER group, rather than the SUMMER or WINTER groups respectively; $\triangle Prop_k$ is the rate of change in the proportion of lambs in a particular season with respect to weaning weight (ie how many more lambs will be assigned to an earlier group as weaning weight changes, calculated assuming a normal distribution of weaning weights with a standard deviation of 5kg); and $b_{(ww,j)}$ is the genetic regression of weaning weight on trait j (using parameters taken from Clarke *et al*. 1991).

RESULTS AND DISCUSSION

This analysis revealed that few animals graded over-fat in the EARLY period, approximately 1 percent of the lambs graded over-fat in the SUMMER period and 2 percent of lambs graded over-fat in the WINTER group (Table 1). These percentages closely matched the predicted proportions of lambs with greater than 12mm GR based on the mean GR depths of the different groups and a SD of 2.41 mm.

The currently used industry index weights FAT and LEAN in the ratio of -1.0 : 1.2. Under the assumptions made in this study, our simulation indicated that the corresponding weights should be in the ratio of +1.0 : 1.19.

A 1kg increase in FAT accounted for a 2.24 mm increase in GR depth. From normal distribution tables this implies that with a 1kg increase in FAT between zero and 13 percent extra lambs (depending on the finishing group GR mean) will be slaughtered with GR > 12mm. The same 1kg increase in FAT would also result in a 1.03kg increase in carcass weight. Using Landcorp's chiller market returns as an illustration, a prime lamb returns $13.50 more than a trimmer grade lamb, and at most 13% more lambs will

TABLE 1: Index weights and profitability of lambs within each finishing group.

Finishing group	Mean index weight FAT	Mean index weight LEAN	Proportion of lambs	Total profit per lamb	Mean GR depth (mm)	Proportion trimmer lambs
EARLY	4.82	6.41	0.04	$ 35.48	5.80	0.005
SUMMER	3.88	4.47	0.54	$ 8.13	6.40	0.01
WINTER	4.43	4.99	0.42	$ 5.11	7.06	0.02

grade trimmer. For the population this is a penalty of approximately $1.76 per head. This penalty must be offset against a correlated gain of 1.03kg in carcass weight, which equates to an extra $4.55 to $5.45 per head. Hence even if all lambs were sold in the chiller market a positive economic value for FAT would result.

It would be incorrect to assume that these results suggest Landcorp Farming Limited should be selecting for fatter sheep. What it does suggest is that when a specific breeding objective is formally defined, weights used for FAT and LEAN are heavily dependent on the mean GR depths of the population, and the proportion of lambs being marketed to the more profitable chiller markets (where price premiums exist for lean lambs). This leads us to question the value of LEAN and FAT as selection criteria.

Various breeding objectives for terminal sire breeds of sheep have been discussed by Rae (1984), Atkins (1987) and Clarke *et al*. (1991). It is implied in these papers that GR depth, carcass weight and carcass yield are the traits which directly determine carcass value through a grading schedule. Given the former definition of a breeding objective it is difficult to see FAT and LEAN as part of the breeding objective; these traits currently have no direct economic benefit to sheep producers other than through their effect on GR depth, carcass yield and carcass weight. It is unlikely that consumers or retailers will reward FAT and LEAN directly through a pricing mechanism (as these traits are not measured on slaughter animals), and it may be argued that these traits will not be good indicators of meat quality. On the other hand lower subcutaneous fat levels are rewarded (through GR premiums), and in the future there may be premiums for intramuscular fat levels (as in the beef grading systems), or low levels of seam fat. Unlike FAT, these traits would be responsible for *directly* influencing product desirability at the retail level.

Due to problems arriving at an appropriate weighting of the true breeding objective traits, Atkins (1987) has argued that a desired gains approach may be used to constrain FAT and increase LEAN. By definition a desired gains approach moves away from a formal derivation of economic weights for a breeding objective, and in this scenario it is not correct to talk about *economic weights* for such indices. Rather, the definition of the breeding objective for desired gains indices should be in terms of the desired gain in each trait not in terms of the index weights used.

The market is not paying premiums for fat levels within a particular type of cut. This is probably because the different dissection of fat carcasses captures all of the discernable variation in carcass quality, and thus does not allow enough variation within a type of cut for the consumer to differentiate quality. It is tempting to assume that the consumer requires a leaner carcass. For chilled carcasses this is the case, however the market signals used in this simulation are such that fatness acts on profit more by determining the types of cuts marketed, than by reduced consumer willingness to buy an overly fat product. This implies that FAT levels in the carcass reflect a true threshold trait, and this is proposed as one of the reasons that the index weights in this simulation were so different to those proposed by Binnie *et al*. (1997).

This simulation was able to use *real* returns per carcass rather than the carcass grading schedule. These returns implied that the lamb grading schedule is aimed at evening out supply of chiller grade lambs throughout the year. The designers of previous breeding programmes have assumed that the grading schedule is based on price signals of consumer desirability. More work needs to be done to determine what it is the consumer really wants, and is prepared to pay for. As has become evident in the beef and pork industries, the distribution of FAT in the carcass (between inter- and intra-muscular fat) is often more important than the actual levels of FAT in the carcass. As seen in this simulation, over simplification of consumer price signals has serious implications for the direction of breeding programmes.

Some processors are now providing price premiums to encourage both maximum *and* minimum levels of GR depth. For example Progressive Meats Limited provides additional premiums for carcasses with between 6 and 9 mm of GR depth within several market grades. Thus there are indications that markets specify a range in GR depths for a given carcass weight. There is a true threshold occurring in the current system where, outside of certain levels, fat is unacceptable in certain cuts but not in others. In such a situation it may be preferable to pursue a desired gains approach, rather than apply a linear weighting to a nonlinear profit function. However, formally defining a breeding objective, would better serve the industry's producers.

It has been suggested that there will be a requirement for lamb carcasses which are heavier than the 15-kg carcass currently produced. While this may be the case, given the differential drafting strategy used by Landcorp, requirements for heavier carcasses will probably not result in more lambs grading over-fat, as would happen in a traditional small scale marketing arrangement. At present it is not economical to ultrasound scan slaughter lambs. Should a requirement for heavier carcasses occur, in advance of genetic improvement, it is likely that pre-slaughter scanning and other management tools would minimise the proportion of over-fat lambs. Thus it would be overly simplistic to assume that the movement towards heavier lambs will result in markedly higher premiums for lean lambs.

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APPENDIX 1: Parameters used in the simulation for each finishing group

Simulation parameters	EARLY	SUMMER	WINTER
Mating	1st March	1st April	26th April
Weaning	22nd October	27th November	29th December
Beginning of finishing period	22nd October	30th October	30th April
End of finishing period	30th October	30th April	1st November
Cost lamb feed/ day after weaning	$0.0076	$0.0105	$0.0160
Mean GR depth	5.80mm	6.40mm	7.06mm