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UPDATED INDEX WEIGHTS FOR THE AUSTRALIAN PROFIT RANKING IN DAIRY CATTLE

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SUMMARY

Several alternative selection indexes for dairy cattle are reviewed as possible replacements for the current version of Australia Profit Ranking (APR) including: an economically optimal solution (the economic index) and two alternative indexes where the relative emphasis on fertility and fitness (compared to protein) is increased. As survival is positively correlated to yields of milk, fat and protein (production), the economic index is close to the maximum response which could be achieved for survival. However, fertility is more difficult to improve because the correlation between fertility and production is negative. To achieve a significant increase in response for fertility, its weight would have to increase considerably. Arbitrary multiples of the economic weight for survival and fertility were considered to investigate the impact on responses to selection. The index weight on survival was doubled and fertility quadrupled in the fitness index and the weight on fertility was doubled in the fertility index. Compared to the economic index, the loss in economic response was $1.40 (6%) for the fitness index and $0.21 (1%) for the fertility index. In the economic index, 53% of the total response is due to improvements in production traits, 37% is due to improved survival and 5% is due to fertility, with the remaining 5% for cell count, liveweight, temperament and milking speed. In the fitness index, the proportion of response due to production traits is 44%, survival 41% and fertility 9%. An index with more emphasis on fitness traits may improve the uptake of the APR. If this occurred it would have a favourable effect on overall genetic improvement of Australian dairy cattle.

INTRODUCTION

The Australian Profit Ranking (APR) is a total merit index introduced to the dairy industry by the Australian Dairy Herd Improvement Scheme (ADHIS) in 2001 (Valentine *et al.* 2000). APR includes estimated Australian Breeding Values (ABVs) for nine objective traits, including milk, fat and protein yields, liveweight, somatic cell count, fertility, survival, temperament and milking speed each weighted by its respective index weight. The purpose of this work was to update the farm model to derive economic values to include prices that are relevant in the foreseeable future and include marginal feed costs rather than average costs. Additionally, there are concerns in the dairy industry that insufficient weight is placed on health and fertility traits. This is believed to be one of the reasons why the uptake of this index by farmers is lower than expected. Therefore, the economic responses to selection using alternative index weights were also explored.

MATERIALS AND METHODS

Data. To derive a set of economic values for traits in the breeding objective, a farm model was constructed to reflect an average Australian dairy farm. Within each age group of cows in the model, returns from sales of milk and culls were calculated in addition to feed, rearing, health and fertility costs. The economic value of a trait was the difference in profit (per cow) between the base model and the model with one unit change in the trait of interest.

Historically, an average cost of energy has been used to estimate the cost of additional feed required to produce extra output (\$0.012/MJ ME). However, using a marginal value of feed (\$0.025/MJ ME) is theoretically more correct, because marginal costs account for the extra costs involved in changing a system to cope with genetic change. The marginal feed cost is generally higher than the average feed cost because feed is either bought in or money is invested on the farm to produce more feed. Economic values for liveweight, survival and milk production traits were sensitive to the value of feed used in the model. This is because liveweight is indicative of maintenance requirements, while high feed costs relative to the value of milk sales would result in the economic optimum being achieved through reducing feed costs by increasing the selection intensity on survival relative to the milk production traits.

Selection index theory was used to predict response to selection of bulls, given phenotypic information on their progeny, updated estimates of genetic parameters, and economic values of objective traits (Hazel 1943). No phenotypic information was assumed to be known for liveweight. Type traits were used to increase ABV accuracy of liveweight, survival and fertility. For other traits ADHIS estimate single trait ABVs, and the correlations between traits were taken into account when deriving optimal index weights. To achieve this, a 35×35 (co)variance matrix of APR and type traits was used (Pryce *et al.* 2008). Since most breeding values are known with high accuracy index weights were close to the economic values.

When constructing a profit based selection index each ABV is weighted to maximize response for overall profit. However, one attribute of a selection index is that close to optimal economic returns may be achieved whilst making subtle changes to the emphasis on some traits. This was explored by comparing selection responses from three alternative indexes: 1) the *economic index*, which uses the set of weights that maximizes profit, i.e. the updated economic values were used to derive weights; 2) a *fitness index* where compared with 1) the weight on survival is doubled and that on fertility is quadrupled and 3) a *fertility index* where compared with 1) the weight on fertility is doubled. By increasing the weights on fertility and survival by the amounts described, re-ranking of bulls is expected.

RESULTS AND DISCUSSION

Updated economic values (EV) along with sets of weights for the current APR index (APR), the *economic index*, the *fertility index* and the *fitness index* are shown in Table 1. The economic value for liveweight is larger than the current APR because maintenance costs were higher due to using marginal feed costs rather than average feed costs. The economic values (EVs) of milk, fat and protein have increased since 2001, because their real prices have increased.

Table 1. Economic values (EV) and index weights for APR, the economic index, fertility index and fitness index

Trait	APR	EV	Economic index	Fitness index	Fertility index
Milk	-0.048	-0.06	-0.09	-0.09	-0.09
Fat	0.9	1.08	1.02	1.02	1.02
Protein	3.8	5.78	6.67	6.67	6.67
Survival	3.9	7.39	6.02	12.04	6.02
Liveweight	-0.26	-1.17	-1.49	-1.49	-1.49
Cell Count	-0.34	-0.26	-0.61	-0.61	-0.61
Fertility	3.0	3.02	2.31	9.26	4.63
Temperament	2.0	2.59	4.13	4.13	4.13
Milking Speed	1.2	1.68	1.83	1.83	1.83

The predicted response of each index (in dollar value per trait) are presented in Table 2, assuming one year of selection results in 0.25 genetic standard deviations of genetic progress. Most of the value of genetic selection on the economic index is protein ($12.29) and survival ($8.09). The total response to selection is $21.80 per year. This is substantially higher than achieved currently (around $10) mainly because of the increase in value of traits. The response to selection in liveweight is positive due to positive correlations between milk, fat and protein yields and liveweight. A positive response in liveweight is unfavourable and the economic response is correspondingly negative.

Table 2. Dollar value of annual responses to selection in APR traits and overall merit when selection is based on the economically optimal index, the fitness index and the fertility index

	Economic index		Fitness index		Fertility index	
	$ response	%	$ response	%	$ response	%
Total merit	21.80		20.40		21.59	
Milk yield	-3.32		-2.40		-3.03	
Protein yield	12.29	53	9.25	44	11.49	51
Fat yield	2.67		2.05		2.53	
Survival	8.09	37	8.29	41	8.07	37
Fertility	0.99	5	2.06	10	1.49	7
SCC	0.37	2	0.37	2	0.37	2
Liveweight	-0.54	-2	-0.38	-2	-0.53	-2
Milking Speed	0.30	1	0.32	1	0.30	1
Temperament	0.94	4	0.86	4	0.89	4

The total economic response to selection for the *Fitness* and *Fertility* indexes was 6% and 1% lower than the economic index, respectively. The percentage of economic response in yield relative to non-production traits was 53%, 44% and 51% for the *Economic*, *Fitness* and *Fertility* indexes respectively. The response in fertility doubled through selection on the *Fitness* index as opposed to the *Economic* index. The correlations between indexes for sires were 0.91 and 0.99 between the *Economic* index and the *Fitness* and *Fertility* indexes respectively. This indicates substantial re-ranking will occur if the *Fitness* index is adopted. The Fertility index will have a much smaller impact on sire rankings.

Figure 1 is constructed by varying the index weights for survival and fertility from none to very high. It shows that selection on the economic index would result in the highest possible economic response and is the highest line of equal profit. This index also has a close to maximal response for fitness (defined as the sum of the response for survival, fertility, cell count, milking speed and temperament). Increasing the weights on fertility and survival results in increased response for these traits, a reduction in response for production, and a relatively small impact on the response in total merit. The ellipse shows that there is a slight positive correlation between production and fitness, which is mainly due to the positive correlation between production and survival.

Of course the proposed 'fitness index' or ‘fertility index’ are only two of the various options to give more emphasis on the fitness traits. Alternatives are doubling or quadrupling the weights for survival and fertility equally. However, there are some good arguments to push fertility more than survival. Firstly, it is more negatively correlated with production traits than survival; hence giving more weight to fertility has more effect on its response. Secondly, survival is positively correlated with production and response to survival is already close to maximal in the economic index. This is because survival has a component which reflects production, as high yielding cows are less likely to be culled. Sometimes survival is corrected for production traits, and redefining it this way gives a trait uncorrelated to production, reflecting the probability of delaying involuntary culling (due to other reasons than low production). Such a trait, sometimes referred to as "functional" or "residual" survival, may be closer to what many perceive as 'robustness of dairy cows', but practically, a redefinition of trait, based on the same measurement, will not lead to another selection result.

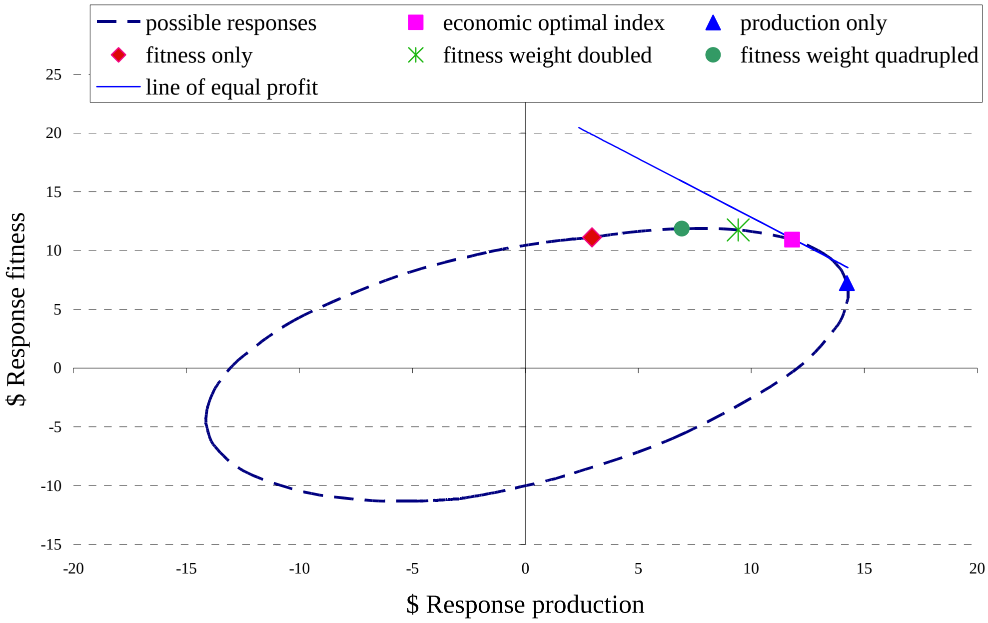

Figure 1. Economic responses in fitness and production of various selection indexes.

CONCLUSIONS

A greater selection response in survival and fertility can be achieved by deviating from the optimal economic index while still 93.6 to 99.0% of economic response to selection. Placing more weight on fertility and survival may be more acceptable to the dairy industry than rigidly accepting the economic optimum.

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