SELECTION RESPONSES EXPECTED FROM INDEX SELECTION INCLUDING DISEASE RESISTANCE, FERTILITY AND LONGEVITY IN DAIRY CATTLE

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INTRODUCTION

Health and fertility traits are of major economic importance so ignoring them in selection is a lost opportunity. There are also welfare, and thus ethical reasons, for including them in selection. Also, these traits are unfavourably correlated with milk yield, so ignoring them in selection will lead to deterioration in genetic merit for these traits (*e.g*. Kadarmideen *et al*., 2000 and 2001). The main objective of this study was to study the selection responses expected from selection on possible future versions of the UK total merit index (TMI), called Profitable Lifetime Index or £PLI. £PLI is based on predicted transmitting abilities (PTAs) for kg milk, fat and protein yield, and lifespan. The indexes investigated here had various combinations of health and fertility traits added as breeding goal (*gl*) or measured index (*ix*) traits.

Calving interval (CI) could be used as an indicator trait for cow fertility, as it has moderate-high genetic correlation with direct fertility measures such as conception success (Kadarmideen *et al*., 2000). Although CI data are censored and may be biased due to culling for poor fertility (Kadarmideen *et al*., 2002), it was considered here, because quality and quantity of CI data are relatively higher than insemination data in the UK (Kadarmideen and Coffey, 2001). Clinical mastitis (CM) and lameness (LS), although not widely recorded, were investigated here, to show the potential economic benefit of widening the recording of these diseases in the UK. Somatic cell count (SCC) in milk has a high positive genetic correlation (~ 0.7) with CM, and PTAs for SCC are already available, so SCC was investigated as an indicator trait in an index with mastitis in the goal, as shown in Kadarmideen and Pryce (2001).

MATERIALS AND METHODS

Expected genetic and economic responses to selection on the current version of £PLI were calculated as a base to which responses from all other indexes were compared. The following indexes were investigated. All diseases are expressed in incidences.

1. £PLI = Milk +Fat + Protein + Lifespan (all as both *gl* and *ix* trait)
2. Mastitis-SCC Index (£PLI+M+S) - *gl* traits as for £PLI, + CM; *ix* traits, as for £PLI, + SCC
3. Mastitis Index (£PLI+M) - *gl* and *ix* traits as for £PLI, + CM as a *gl* and *ix* trait
4. Lameness Index (£PLI+L) - *gl* and *ix* traits as for £PLI, + LS as a *gl*and *ix* trait
5. Fertility Index (£PLI+C) - *gl* and *ix* traits as for £PLI, + CI as both a *gl* and *ix* trait
6. Health Index (£PLI+M+L) - *gl* and *ix* traits as for £PLI, + CM and LS as *gl* and *ix* traits
7. Health and Fertility Index (£HFI) - *gl* and *ix* traits as for Health Index, + CI as a *gl* and *ix* trait

Genetic parameters. The most recent estimates of heritabilities, genetic and phenotypic variances and correlations for milk, fat and protein yield, CI, CM, SCC and LS for UK dairy cattle were taken from Kadarmideen *et al*., (2000) and Kadarmideen and Pryce (2001). All parameter estimates for lifespan were from Brotherstone *et al*. (1997) and Pryce and Brotherstone (1999) and for SCC and production traits were from Mrode *et al*. (1998). Correlation estimates for LS with SCC and lifespan were obtained from genetic regression of daughter LS records on sire PTAs for SCC and lifespan (Kadarmideen *et al*., 2001, unpublished).

Economic values. Economic values of goal and index traits used in the calculation of total economic responses are given in Table 1. These economic values are after excluding culling costs to avoid double counting with economic values for lifespan, which already include culling costs for CM, LS and infertility.

Table 1. Economic values of index and goal traits used in the calculation of TMI

Index or Goal Traits	*Units*	Economic Value (£)
Milk yield	*Kg*	-0.03
Fat yield	Kg	0.3
Protein yield	Kg	3.0
Lifespan	Lactations	28
Calving Interval (CINT)[1]	Days	-4
Clinical Mastitis[1]	0 or 1	-100
Somatic Cell Count (SCC)	PTA for SCC	-0.18
Lameness[1]	0 or 1	-93

[1]Economic values are after excluding culling costs

Selection response. Genetic (**G**) and phenotypic (**P**) variance-covariance matrices were constructed using published parameter estimates for UK dairy cattle populations and a vector of economic values (**a**) was constructed using the values in Table 1. It was assumed that each sire would have 75 daughters. Matrices **P** and **G** were made positive definite, where necessary, by bending techniques. Index weights (**b**) were then calculated as $\mathbf{b=P^{-1}Ga}$. Correlated genetic responses (C_R) were computed as $C_R = \mathbf{b'G/\sqrt{b'Pb}}$. Annual economic responses were calculated as 0.22 standard deviations of aggregate genotype, with genetic response in each goal trait being weighted by its economic value and summed. In all cases it was assumed that selection was based on the index concerned in all pathways (i.e. bulls to breed bulls and cows, cows to breed bulls and cows).

RESULTS AND DISCUSSION

Total annual economic responses (TAER), direct and correlated genetic responses of individual traits are given in Figures 1 through 3. Comparing expected responses from selection on £PLI with those from the mastitis-SCC index shows that TAER has increased by 22% (from £4.36 to £5.32) as shown in Figure 1. Selection on the mastitis index instead of the mastitis-SCC index, is expected to improve mastitis resistance further (Figure2), resulting in 6% increase in TAER (Figure 1). This is because the genetic correlation between mastitis and SCC is only 0.7, and therefore mastitis incidence data provide additional information to predict mastitis breeding values (Kadarmideen

and Pryce, 2001). This shows the value of widespread and complete recording of mastitis incidence. Selection on the lameness index (£PLI+L) was expected to decrease LS incidence (Figure 2) and increase TAER from £4.36 to £4.67 compared to selection on £PLI (Figure 1). Genetic parameter estimates for categorical traits, such as mastitis, are frequency-dependent when estimated via a linear model. To obtain a frequency-independent selection response, a threshold model analysis would be appropriate, as shown in Kadarmideen *et al*. (2001).

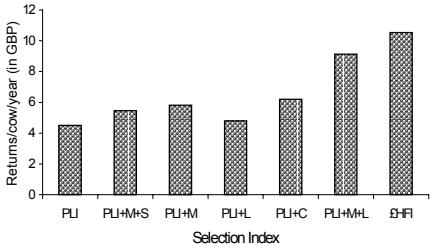

Figure 1. Total annual economic responses (in £) per cow using different TMI

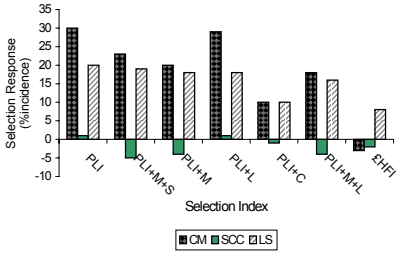

Figure 2. Selection responses in disease incidences (in %) using different TMI

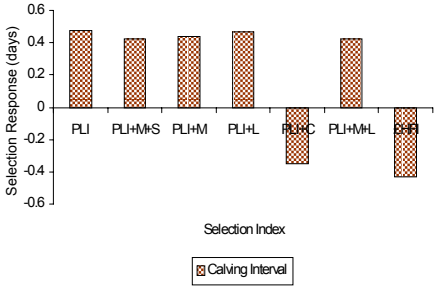

Figure 3. Selection responses in fertility trait-calving interval using different TMI

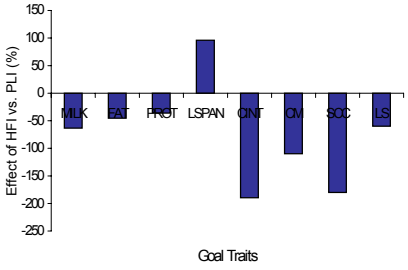

Figure 4. Relative differences in selection responses in the breeding goal traits using HFI versus PLI, expressed in percentage

Selection on the health index (£PLI+M+L), was expected to decrease disease incidences and thereby, increase the TAER by 40% (Figures 1 and 2) compared to selection on £PLI. Adding the incidence of both CM and LS to the goal + index results in higher returns than when either disease is considered singly (Figure 1). This beneficial effect is due to a moderate genetic correlation between the two traits. The increase in lifespan was also greater when both CM and LS are in the index (not shown). Selection on the fertility index (£PLI+C), compared with the £PLI, is expected to lead to an increase of 38% in TAER (from £4.50 to £6.20 – Figure 1). Comparison of genetic

responses between this index and £PLI show that CI is expected to reduce by 0.83 days per year or 16.5 days after 20 years of selection (Figure 3). Annual correlated responses in other traits not in the goal or index were also favourable *i.e*. CM and LS incidences and SCC are expected to decrease by a third to a half (Figure 2). These results show the direct or indirect value of fertility traits in the overall economic returns in dairy cattle breeding.

Selection on the health and fertility index (£HFI) resulted in substantial economic improvement compared to all other indices investigated, perhaps reflecting the high relative economic value of fertility over and above that currently included in the value of lifespan (*i.e*. due to culling for fertility). Figure 4 shows the differences in expected selection response for the same trait following selection on two indexes, £HFI and £PLI. As seen in Figure 4, responses in yield are lower but responses in disease resistance, fertility and longevity improved substantially. When these responses are weighed by their economic values (Figure 1), this results in 140% greater returns expected from selection on £HFI than on £PLI. This is mainly because of genetic improvement in disease resistance and fertility and the associated increase in lifespan, all of which have relatively high economic values.

CONCLUSION

Health and fertility traits, when included in £PLI (Production + Longevity) produces substantial genetic improvement and hence economic benefits (140% greater returns). It is recommended that future breeding goals in the UK and other countries (if applicable) should be expanded to include direct or indirect measures of health and fertility (*e.g*. CM, LS, SCC and CI). The inclusion of health and fertility traits in the breeding goal is likely to become even more important, and could have greater economic impact, if welfare-based quality-assured milk production becomes more widespread.

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