COMBINING TRANSMITTING ABILITIES FOR YIELD AND LINEAR TYPE IN AN INDEX FOR SELECTION ON PRODUCTION AND LONGEVITY.

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SUMMARY

A profit index combining transmitting abilities for yield and angularity, udder depth, foot angle and teat length is developed for selection towards a goal comprising milk (£-0.03 /kg), fat (£0.60 /kg), protein (£4.04 /kg) and longevity (£5.52 /% of cows surviving till lactation 4). Sensitivity analysis showed that the index developed was robust towards changes in the assumptions made.

INTRODUCTION

The objective of many dairy farmers is to maximise profitability, consistent with the health and welfare of their animals. Clearly longevity of the cow is an important component of profitability (e.g. Rendel and Robertson, 1950). Because no predicted transmitting abilities (PTAs) for longevity (or similar traits) are available in the UK, the objective of this study was to combine PTAs for linear type traits and PTAs for milk, fat and protein in an index. PTAs for the type traits were used to predict longevity of the cow as a first step towards a 'total merit' index.

MATERIAL AND METHODS

Economic values: There are several different viewpoints which can be taken in calculating economic values (e.g. national returns, individual producers returns), but in this case they have been derived from the individual producers viewpoint. The perspective of individual producers will be to improve profitability (Moav, 1973). A dynamic programming model (Stott 1994) was used to calculate economic values for the goal traits - milk, fat and protein yield and percentage involuntary culling up to lactation four. The economic value for each goal trait was calculated as the change in the net present value of a replacement heifer (£ per unit, expressed as annuity) as a consequence of a unit increase in the goal trait concerned, whilst keeping the output of the other goal traits constant.

For each day energy requirements were calculated from energy needed for maintenance (based on live weight), energy required or gained from live weight change, energy required for pregnancy and when not in the dry period, energy required for fat, protein and lactose production. All equations used came from a commercial cow rationing program (G. C. Emmans, personal communications). Based on the calculated energy requirements a least costs cow ration was formulated combining grass or silage and concentrates. Dry matter intake capacity was based on (i) live weight of the cow and (ii) dry matter percentage and digestibility of the food.

Finally, dynamic programming was used to optimise the 'keep or replace' decisions (Van Arendonk, 1985a). Decisions were taken annually over a sequence of 20 annual stages and a maximum of 12 lactations was assumed with 15 yield states (chance nodes) within each lactation (Stott 1994). The influence of the repeatability of milk yield on the replacement decision was accounted for using the method of Bayesian updating (Lindley, 1965). In the absence of reliable UK information, the probabilities of involuntary replacement used were those of Van Arendonk (1985b). All other physical and financial assumptions were based on UK estimates.

A price ratio for fat:protein of 1:1.5 was assumed and costs of transport and processing have been assigned to each extra kg milk. In the absence of evidence suggesting otherwise, it was assumed that the expected small changes in individual traits would leave the number of animals in a typical herd unchanged. It was also assumed that quota can be freely leased when herds are 'above quota', reflecting current industry practice. The dynamic programming model was therefore based on a fixed number of animals in the herd, with quota considered as an opportunity cost associated with fat production. A sensitivity analysis of the economic values was used to justify these assumptions. The economic values derived were £5.52 per % cows not involuntarily culled in the first four lactations and £-0.03, £0.60 and £4.04 per kg for milk, fat and protein yield respectively.

Genetic parameters: Genetic correlations between linear type traits and longevity (or survival), adjusted for genetic merit for yield (Brotherstone and Hill 1991) were used (Table 1). Only four of the 16 linear type traits were chosen for the index (based on the strength of the genetic correlations with survival).

TABLE 1: Heritabilities (diagonal), phenotypic (above the diagonal) and genetic correlations (below the diagonal) from Brotherstone and Hill (1991) and S. Brotherstone personal communication.

	Longevity	Milk	Fat	Protein	ANG	FA	UD	TL
Standard deviation	49	895	35	27	1.34	1.17	1.64	1.24
Longevity[1] (%)	.06	-	-	-	-	-	-	-
Milk (kg)	.00	.47	.83	.94	.27	-.03	-.28	.05
Fat (kg)	.00	.77	.52	.87	.25	-.02	-.25	.02
Protein (kg)	.00	.93	.85	.45	.24	-.02	-.27	.05
Angularity (ANG; 1-9)	.11	.44	.42	.43	.26	-.04	.06	-.01
Foot angle (FA; 1-9)	.09	.02	.05	.07	-.13	.27	.10	-.01
Udder depth (UD; 1-9)	.21	-.48	-.40	-.44	.01	.03	.39	-.09
Teat length (TL;1-9)	-.19	.18	.12	.17	.08	-.09	-.21	.44

1 Cows not involuntarily culled in the first 4 lactations, corrected for genetic differences in yield.

Derivation of index weights: In the usual way, genetic (G) and phenotypic (P) variance and covariance matrices were created. For the P-matrix it was assumed that 10 000 effective progeny records were available for estimating the PTAs for yield and type. Selection index equations (Hazel, 1943) were used to calculate optimal index weighting factors and evaluate the consequences of selection, using three different indices assuming that: (i) interest is in yield components only (YIN), (ii) interest is in longevity only (LIN) or (iii) interest is in yield and longevity, hence profit (PIN). Some re-scaling has to be applied to the weighting factors as these have to be applied to PTAs for milk, fat and protein (in kg) and for the type traits expressed in standard deviation units. Annual selection responses were approximated assuming a four pathway breeding scheme (bulls to breed bulls, bulls to breed cows, young bulls to breed cows, cows to breed bulls, cows to breed cows) with an overall selection response of 0.22 standard deviations of the appropriate index.

RESULTS

The weights calculated for the three indices are given in Table 2. Weights for the yield index (YIN) are equivalent to the economic values of the yield traits and no importance is given to the type traits, as expected because PTAs are assumed to have large (>.99) accuracy's. The index weights for profit are the sum of the weights of the indices for yield and longevity.

TABLE 2: Optimum index weights, when selection goal is yield or longevity only or profit.

Goal:	profit	yield	longevity	
Index:	PIN	YIN	LIN	direction
PTA for:				
Milk (kg)	-0.015	-0.030	0.015	
Fat (kg)	0.60	0.60	0.00	
Protein (kg)	3.84	4.04	-0.20	
Angularity (sd)	3.9	0.0	3.9	angular
Foot angle (sd)	1.8	0.0	1.8	steeper
Udder depth (sd)	4.8	0.0	4.8	above hock
Teat length (sd)	-4.1	0.0	-4.1	shorter

If selection is for yield only, then the expected maximum selection response of £15.3 per cow per year can be achieved (Table 3). This response is a combination of 119 kg milk, 5.0 kg fat and 3.9 kg protein per year. When selection is for profit then a slightly lower rate of genetic gain is expected for the production traits, but longevity of the cow is expected to be improved (0.23 less cows culled involuntarily in the first four lactations in a 100 cow herd per year). This is predicted to increase the annual selection response by £0.70 per year (5%) compared to selection on a combination of milk, fat and protein only.

TABLE 3: Expected selection response (per cow per year) for the goal traits.

Goal:	profit	yield	longevity
Index:	PIN	YIN	LIN
Response per annum in:			
Profit (H) (£)	16.0	15.3	4.5
Longevity (%)	0.23	0.00	0.81
Milk (kg)	114	119	0
Fat (kg)	4.8	5.0	0.0
Protein (kg)	3.8	3.9	0.0

The benefit from selection on PIN is shown, for example, when the selection responses for UD are compared (Table 4). Selection for milk yield will result in deeper udders and selection for longevity will result in shallower udders, but selection on PIN will give a balanced rate of genetic gain, based on the economic values of longevity and yield. The same conclusions could be drawn for fore udder attachment, even though it is not included in the index. Another observation is that TL is not expected to change following selection on PIN, even though it has a negative weighting in the index. PIN simply counterbalances the expected increase in TL following selection on yield alone.

TABLE 4: Expected selection response (units per cow per year), for some type traits.

Goal:	profit	yield	longevity	Score:	
Index:	PIN	YIN	LIN	1	9
angularity	0.08	0.06	0.05	Coarse	Angular
foot angle	0.02	0.01	0.04	Low	Steep
udder depth	-0.05	-0.10	0.15	Below	Above Hock
teat length	0.00	0.03	-0.11	Short	Long
fore attachment	-0.02	-0.05	0.09	Loose	Strong

Theoretically, PIN gives optimum response in the base situation only and therefore a sensitivity analysis was carried out. Table 5 shows that the index proposed is robust to large changes in the economic value of milk and fat. Most of the loss in efficiency of the profit index appears when the economic value of protein is overestimated.

TABLE 5: Efficiency of using PIN (i.e. using weighting factors from the base situation), compared to the optimum PIN in situations where the true economic values for one of the goal traits (milk, fat and protein yield and longevity) differs by -100, -50, +50 and +100 per cent from the base values, while keeping the other economic values at the base values.

	Percentage change:			
	-100%	-50%	+50%	+100%
Longevity	0.960+	.990	.992	.970
Milk	0.994	.998	.997	.985
Fat	0.992	.998	.999	.996
Protein	0.140	.956	.994	.987

+ e.g. the rate of genetic gain with PIN is 96% of the maximum genetic gain, when using the optimum index in the situation where the economic value of longevity is zero (-100% of the base value) and all other economic values are at their base value.

DISCUSSION

The objective of this paper was to demonstrate how PTAs for linear type and milk production traits can be combined in an economic profit index, PIN. Selection on PIN is expected to give a £0.70 higher annual rate of genetic progress (5%) compared with selection on an index combining PTAs for milk, fat and protein only. The extra benefit come from the longer herd life of cows. Its use is expected to halt the decrease in udder depth and fore udder attachment scores that would occur as a consequence of selection for yield alone. In genetic standard deviation units the final weighting for yield to type is 3:1. The index appears robust to 50% changes in economic values for protein yield and longevity, but very sensitive to a 100% change in the value of protein. Larger changes in the economic value for milk or fat yield give efficiencies above 0.985, therefore allocation of quota costs to fat yield only does not seem critical (given the UK average quota situation about 20-25% of the quota leasing costs could be attributed to milk yield). Also, PIN appears to be robust when applied to bulls which fewer effective daughters available (results not shown, but efficiency is > 0.985 when only 25 effective daughters with type or for yield records are available). Implementation of the derived index depends on the outcome of a consultation process with the UK dairy industry.

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