Twenty years' experience with simultaneous selection for production and functional traits in Norway

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Abstract

Since 1974 functional traits as fertility and health have been included in the Norwegian breeding program with dairy cattle. In the beginning the weighting on these traits was rather low, but it was substantially increased from 1980 to 1990. The effects of selection have turned out to be what is expected as a result of selection intensity and accuracy of breeding values for both functional traits and production traits. Today the breeding objective in the Norwegian Cattle (NRF) population consists of 10 traits. The relative weight on kg protein is only 21%, which enables genetic progress also for the low heritable functional traits such as disease resistance and fertility. By applying the current breeding objective the expected genetic changes per annum are: 0.0039 reduction in mastitis frequency, 0.0009 reduction in frequency of other diseases, 0.004 increase in non-return rate, 0.0016 reduction in frequency of calving difficulties and 0.002 reduction in frequency of stillbirths. Consequences of increased weight on kg protein in the breeding objective were investigated. Expected genetic change became unfavourable for mastitis resistance, other diseases and non-return rate when weight on kg protein passed 41%, 33% and 55% respectively.

1. Introduction

The economic margins in livestock production are under constant pressure. The search for ways of reducing costs has lead to an enormous improvement in efficiency over the last decades. This improvement has partly been due to genetic changes through selection programs. These programs have mainly concentrated on improving a small number of traits connected to production efficiency. The «sustainability» of such programs in terms of unfavourable correlated response in functional traits, such as disease resistance and fertility, can be questioned. Breeding goals in the Nordic dairy cattle populations have been exceptions from this general trend. In these populations functional traits have been included in breeding goals for more than 20 years. Currently, the weights on milk production in the breeding goals in these countries vary from 21% in the NRF population to 42% in the FAY population.

During the last ten years the importance of functional traits in a breeding program has been much discussed, and now we see a trend towards more interest in including functional traits in the breeding program in many countries. Many countries have already implied new total merit indexes with traits like fertility and SCC included.

Table 1. **Current breeding goal in the NRF-population**

Trait	NRF
Kg protein	21
Mastitis	21
Udder	11
Body/leg conformation	6
Beef	12
Temperament	4
Non-return	14
Calving ease	4
Stillbirth	4
Other diseases	3

1.1. Development of the breeding objective in Norway

In Figure 1 the changes in weights for milk yield, beef, fertility of daughters, health traits and calving are shown for the period 1962 to 1999. The great changes occurred in 1980 and 1990. At those times the weight on milk yield was very much reduced. This was done in order to allow for a genetic progress also for health and fertility. In the 70's the functional traits were gradually included, but with small weights because most of the farmers did not believe that it was worthwhile to include such traits. This attitude changed gradually, and in 1990 it was the other way round. Many farmers wanted even more emphasis on the low heritable traits. This reflects some effect of experience but also some effect of tradition. The farmers were not used to discuss traits like fertility and health in connection with selection of animals for breeding before 1980.

Economic returns from the breeding program have been in focus for the whole period. But it has become more and more obvious that if maximum economic return from a genetic gain in yield is desired, it must be a net gain without many extra costs linked to it (Steine, 1998). How the weighting on functional traits should be relative to the weighting on production is always subject to discussion. The long-term effect and the probability for changes in the economic value of some functional traits make it very complicated. As an example we may look at the weight on mastitis resistance in the Norwegian breeding program. The average cost of a cow having at least one incidence of mastitis per lactation is around 4000 NOK. The weight in the current breeding objective corresponds to an economic value of 5500 NOK. Consequently we put more weight on mastitis resistance than it deserves from a pure economic analysis. We may name this difference a strategic economic value. It reflects that we believe that in the future there will be an extra value of being able to claim that healthy cows produce the milk with very little need for medicines.

1.2. Selection effects

In Norway it has been a part of the breeding objective that all traits with a separate weight should have a positive change over a time period of 5-6 years. Figure 2 shows the selection differential for some important traits, expressed in percentage of the selection differential obtained if selecting for only one trait at the time. The graphs show a positive selection differential for all these traits. It also illustrates that the selection for milk yield has become less intensive while the selection for mastitis resistance and fertility has increased.

To check how these effects agree with what should be expected we also carried out a study by means of the selection index method.

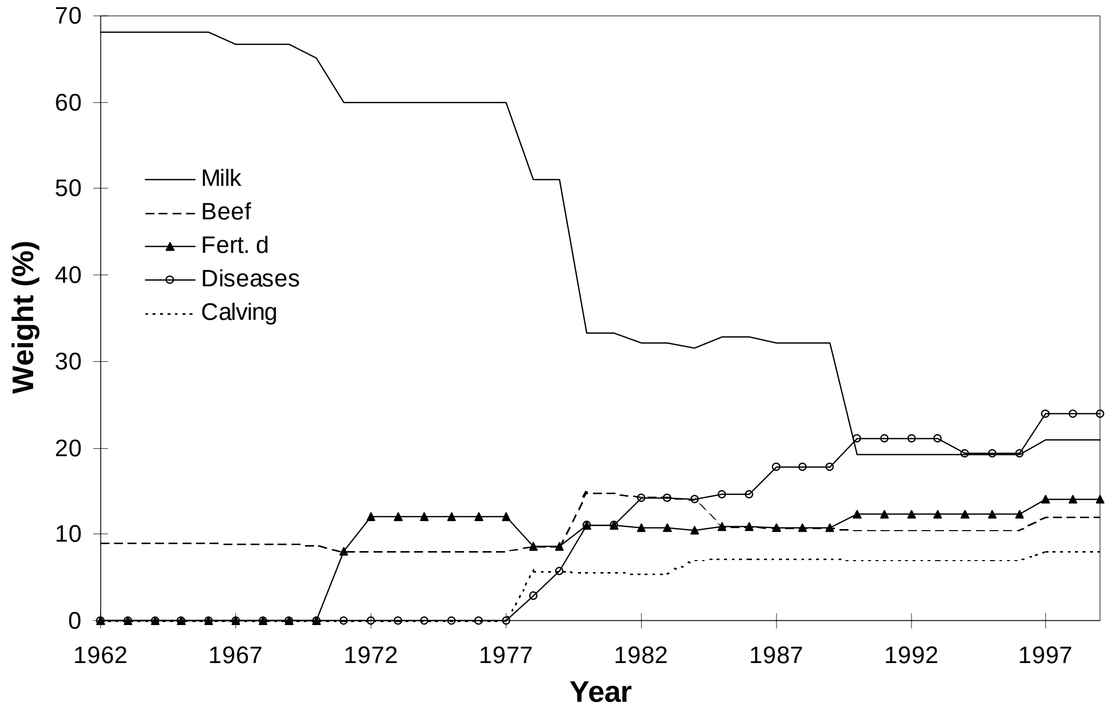

Figure 1. **Relative weights on the most important traits for the period 1962-1999.**

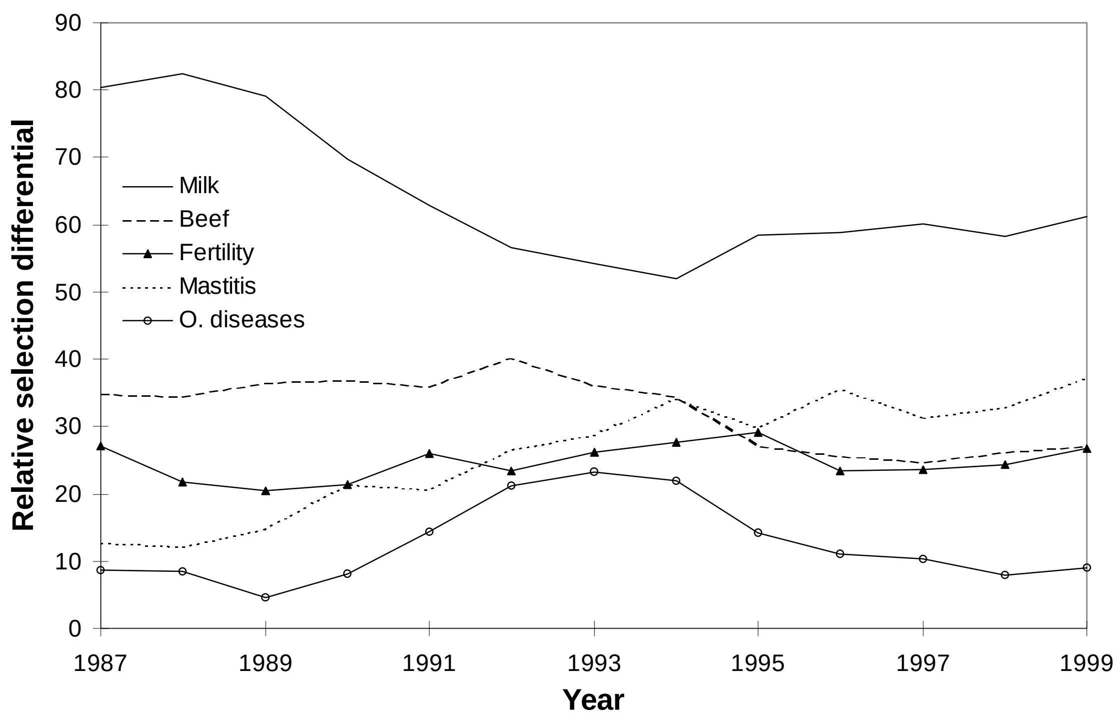

Figure 2. **Selection differentials for the most important traits, expressed as percentages of selection differentials if selected for only one trait at the time.**

2. Methods

Effects of different breeding goals (aggregate genotype) on expected genetic change of single traits were computed by use of deterministic simulations. Population structure and breeding plan was modelled by constructing selection indices (Table 2 and 3). Genetic parameters used in the selection indices are shown in Table 4. Selection intensities and generation intervals were found from realised values (based on historical data). Selection intensities were corrected for deviations from normal distribution due to selection in finite (small) sample sizes. Eventually expected genetic changes were computed according to:

$$\Delta T = \frac{i_{SS}\sigma_{SS} + i_{SD}\sigma_{SD} + i_{DS}\sigma_{DS} + i_{DD}\sigma_{DD}}{L_{SS} + L_{SD} + L_{DS} + L_{DD}}$$

where, i = selection intensity, σ = standard deviation on breeding values, SS = bull sire, SD = cow sire, DS = bull dam, DD = cow dam, L = generation interval. Selection and culling effects of cow-dams were ignored (i_{DD}=0).

Table 2. **Progeny group sizes, population means and expected genetic gains in the NRF population**

Trait	Unit	Prog. Group size	Popul-ation Mean	Expected ΔG/year
Kg protein	Kg	250	209	1,293
Mastitis	%	300	14	-0,39
Other dis.	%	300	6	-0,09
Udder		150		
Body/leg		150		
Beef	NOK	250	8430	32,40
Milking ease		200		
Temp.		150		
Non-Return	%	300	78	0,40
Calving ease	%	300	91	0,16
Stillbirth	%	300	3	-0,20

Table 3. **Breeding plan and structure of the NRF population**

Cows inseminated with young bulls, %	40
Young bulls per year, no	125
Elite bulls per year, no	10
Bull sires per year, no	5
Bull dam selection, %	5
Generation interval, elite/bull sires, years	7,2
Generation interval, young bulls, years	2,9
Generation interval dams, years	3,5
Heifers as bull dams, %	50
Performance tested bulls per year, no	400
Breeding cows, no	300000

3. Results and discussion

Applying the current breeding goal in the NRF population gives substantial favourable expected genetic change for all functional traits (Table 2). The genetic improvement is most pronounced for mastitis frequency and non-return rate with app. 0.004 per year. For other diseases, calving ease and stillbirth the improvements in frequency were 0.0009, 0.0016 and 0.0020 respectively. The cost of this is a moderate improvement for milk production of app. 1.3 kg protein per year (equivalent to app. 40 kg milk). This is roughly half of the maximum achievable expected improvement by selecting for kg protein only. If these results can be verified by estimates of realised genetic gains, the breeding goal and breeding plan of the NRF population would probably deserve the definition «sustainable». The definition, however, is a vague one. «Sustainability» should also mean that the system can stay «in business», i.e. that it is economically and politically competitive. To investigate this a profit analysis should be performed.

Effects of increasing the economic weight on kg protein are shown in Figure 3. The relative weights among the other traits were kept constant. The results show that expected genetic change became unfavourable for mastitis resistance, other diseases and non-return rate when weight on kg protein were greater than 41%, 33% and 55% respectively. When weight on milk production passes these limits, problems with functional traits will increase. Consequences of this are increased veterinary costs, lower productivity in terms of calves born per year and higher consumption of antibiotics. This may to some extent be profitable, but public opinion and authorities will probably not accept it. Increasing economic weight on kg protein from 21% to 30% will result in a reduction in expected genetic gain for mastitis resistance to 50%, a reduction in gain for other diseases to 30% and an increase in gain for kg protein by 40%. Therefore, 30% weight on kg protein in the breeding goal should be regarded as the maximum acceptable level in a «sustainable» breeding plan.

It is important to note that the genetic gains presented here result from the assumptions shown in Tables 1-4. Functional traits are often low heritable (2-5%), and genetic gain is possible only when having large progeny groups. Production traits, on the other hand, have often high heritabilities. In populations with smaller progeny groups, therefore, it is necessary to reduce weight on production traits well below those for the NRF population in order to achieve similar results for functional traits. Large progeny groups can be achieved by inseminating a large proportion of the cows with young bulls and/or using relatively few young bulls. This is in conflict with selection intensity and hence an optimal solution should be found. These results are in very good agreement with the experiences from the ongoing breeding program. At this workshop there will also be presented results for realised genetic gain in mastitis resistance (Svendsen, 1999).

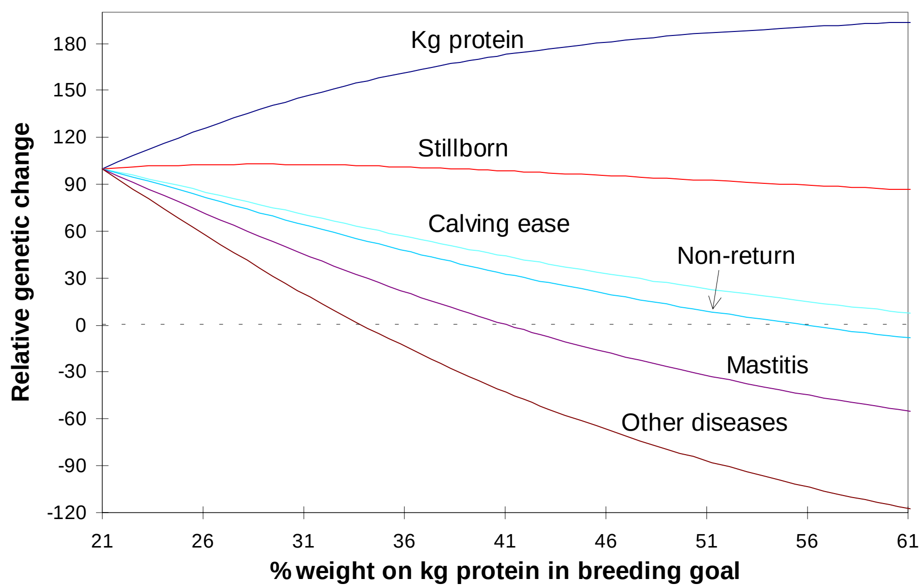

Figure 3. **Effect of increased weight on kg protein on genetic gain for single traits.**

1. Conclusions

- The current breeding goal for the NRF population is expected to give substantial genetic progress for functional traits.
- Expected genetic gain for milk production is 50% of the maximum achievable.
- Weight on milk production in the breeding goal should not be higher than 30% in order to facilitate a balance between production and functional traits.
- The current weighting on traits allows for desirable selection differentials for both production and functional traits.

References

Steine, T. 1998. Realised effect of selection for mastitis resistance. Proceedings of the 1998 INTERBULL meeting, January 18 - 19, 1998. Rotorua. INTERBULL bulletin No. 17: 115-117.

Svendsen,M., 1999. A retrospective study of selection against clinical mastitis in the Norwegian dairy cow population. Proceedings International Workshop on Genetic Improvement of Functional Traits in cattle (GIFT) - Breeding goals and selection schemes, November 7 - 9, 1999, Wageningen. INTERBULL bulletin, 97-104.

Table 4. ***Heritabilities*** **and genetic correlations**

	P	M	U	B	M	L	T	F	C	S	O	P%
Heritability	*.20*	*.03*	*.10*	*.15*	*.20*	*.10*	*.10*	*.05*	*.05*	*.05*	*.02*	*.30*
Protein		-.31	.17	.16	.05	-.12	.14	-.10	-.03	.11	-.25	.24
Mastitis			.09	-.09	-.01	.11	.05	.01	-.01	.02	.27	.19
Udder				-.05	.25	.15	.26	.12	-.07	-.07	.11	.01
Beef					.01	.37	.03	-.21	.02	-.12	.17	.01
Milk. Speed						-.19	.25	-.02	-.27	-.06	-.20	-.08
Legs							.06	-.13	.14	-.13	.36	.00
Temperament								.08	-.06	.00	-.18	.01
Fertility									-.03	.01	-.04	.01
Calving Ease										.61	-.03	-.11
Stillbirth											.00	-.07
Other diseases												.19