Effects of including conformation in total merit indices of cattle

J. Sölkner, A. Willam, E. Gierzinger and C. Egger-Danner

Department of Livestock Science, University of Agricultural Sciences Vienna, Gregor-Mendel-Strasse 33, A-1180 Vienna, Austria

Abstract

Conformation traits are frequently considered to be early predictors of functional longevity of cows and are therefore included in selection indices, either as sole predictors of longevity or as "indirect" measures of longevity together with "direct" information like number of lactations survived or breeding values from survival models. Apart from this, conformation traits play an important role in selection decisions of farmers and breeding organisations, mostly not as part of an index with a formal economic weight but as independent selection criteria with undefined value. A complex deterministic model is used to describe the breeding programmes for Austrian Simmental and Brown Swiss cattle. For Simmental, the breeding goal is defined by a selection index including dairy, beef and functional traits, for Brown Swiss only dairy and functional traits are considered to be of economic importance. The effect of inclusion of conformation on annual monetary genetic gain is examined by adding one conformation trait to the index. In one situation this trait has no economic weight itself but is correlated with longevity, which is a trait with a high weight in the index. In a second approach the conformation trait is considered uncorrelated with all other traits in the index and receives different subjective weights. When including conformation as a trait adding information on longevity two situations are considered. In one, the genetic correlation of a composite conformation trait and longevity is 0.6, in the other it is 0.3. In both situation the increase in total merit from the index is small (0.3 percent for Simmental, 2.2 percent for Brown Swiss). The additional gain in longevity is higher for Brown Swiss than for Simmental. Inclusion of conformation as a composite trait (different from the above) describing the "beauty" of a cow with a hypothetical weight proportionate to the sum of weights of all other traits but uncorrelated to all traits produces large effects when the weight is high. If the proportionate weight of conformation is 10 percent, the economic gain from the other traits is dropping by roughly five percent. If the relative weight is 30 percent, loss in economic gain from other traits is almost 40 percent. It is concluded that inclusion of conformation as early information on longevity has a limited positive effect but placing to much weight on conformation has a severe negative impact on selection response from economically important traits.

1. Introduction

Total merit indices are more and more frequently used in dairy and dual-purpose cattle breeding (Philipsson *et al.*, 1994; Sölkner *et al.*, 1999). The role of conformation traits in such indices is normally seen as early indicator traits for length of productive life (Dekkers *et al.*, 1994). In addition, conformation traits are sometimes included in total merit indices with subjective weights (i.e. weights not derived as marginal economic gains due to genetic improvement) to account for the importance of these traits in the personal breeding goal of many practical breeders. When conformation is not included in the index (as is the case in Austria, see Miesenberger, 1997; Miesenberger *et al.*, 1998; Sölkner *et al.*, 1999; Egger-Danner *et al.*, 1999) it is probably still considered in selection decisions but as an independent selection criterion with undefined weight.

In this paper we consider the consequences of both potential uses of conformation traits in selection decisions on the monetary selection response. First, conformation (probably a function of a set of conformation traits considered highly correlated with longevity) is interpreted as a single trait that is included in the selection index without its own economic weight but with a correlation to longevity. Second, conformation (another function of a set of traits probably different from the one above that is supposed to represent the farmers' preferences) is included in the index. This trait is considered to be completely independent from all other traits. Artificial weights are placed on this trait to quantify the decrease of monetary returns from the other traits in the index for different relative importance placed on conformation.

Analyses are carried out for one dual-purpose breed (Simmental) and one dairy breed (Brown Swiss). A complex deterministic model of the breeding programme is implemented to investigate the effect of inclusion of conformation on the total annual monetary gain as well as on natural gains in longevity and conformation.

2. Methods and analyses

2.1 Selection index

The total merit index for Austrian cattle breeds as defined in Miesenberger (1997) is used as the reference for all calculations. It includes 14 traits (2 dairy, 3 beef and 9 functional traits) for Simmental and 11 traits (2 dairy and 9 functional traits) for Brown Swiss. Table 1 lists the traits and gives economic values used in the calculations. These values were derived from a herd model originally developed by Amer *et al*. (1994) and extended by Miesenberger (1997) as also described in Miesenberger *et al*. (1998). All weights are expressed as marginal monetary gains due to improvement of a trait by one genetic standard deviation. Changes in herd profit are scaled to the unit of one cow. The matrix of heritabilities, phenotypic and genetic correlations used, is given in Table 2. The same set of parameters is used for both breeds.

2.2 Modelling of the breeding programme

The program ZPLAN is used to describe the breeding programmes. ZPLAN (Karras *et al*., 1994) is designed to optimise selection strategies in livestock breeding by deterministic calculations. It is based on a comprehensive methodology of evaluating both the genetic and economic efficiency of breeding strategies considering one round of selection. Breeding programs and their parameters are defined by the user, and the program calculates a number of criteria such as annual monetary genetic gain for the aggregate genotype, annual genetic gain for single traits, discounted returns and discounted profit for a given time horizon. The gene flow method (Hill, 1974, McClintock and Cunningham, 1974) and selection index procedures constitute the core of the program. Selection groups have to be defined specific for their sources of information and selection intensities. ZPLAN considers several tiers such as nucleus, multiplier and commercial unit. Some of the essential input parameters were assumed as follows:

Population Parameters	**Simmental**	**Brown Swiss**
Total population size	650,000	83,320
Proportion of recorded cows	0.35	0.88
Proportion of AI	0.88	0.82
No. of young bulls tested per year	130	50
No. of approved bulls selected per year	16	10
Ratio of inseminations : lactation records	10 : 1	15:1
No. of selected bull dams per year (elite-matings)	2,000	1,206

Biological coefficients		
Av. time period between calvings (years)	1.07	1.13
Stillbirth rate	0.04	0.04
Losses during raising (female)	0.15	0.10
Losses during raising (male)	0.25	0.15
Use of young bulls (years)	*0.4*	*0.4*
Use of proven bulls (years)	2.0	2.0
Use of bull dams (years)	3.0	2.0
Use of dams (years)	3.8	4.4
Mean generation interval in years (all selection groups)	5.65	5.74

Table 1. **Genetic standard deviations (s_A) and economic weights (w) per genetic standard deviation of the traits in the index**

Trait			Simmental		Brown Swiss	
	Abbrev.	Unit	s_A	W	s_A	W
Fat yield	Fat	Kg	15.60	26.05	14.80	26.94
Protein yield	Protein	Kg	10.50	27.51	9.80	27.73
Daily gain	Dg	G	47.00	11.28	---	---
Dressing percentage	Dp	%	1.14	11.26	---	---
EUROP grading score	EUROP	Class	0.25	4.22	---	---
Longevity	Long	Day	180	21.60	180	27.00
Persistency	Pers	s_A	1.00	2.91	1.00	4.36
Fertility paternal	Fert-p	%	5.00	7.25	5.00	8.00
Fertility maternal	Fert-m	%	5.00	7.25	5.00	8.00
Calving ease paternal	Ce-p	Class	0.22	1.71	0.22	1.07
Calving ease maternal	Ce-m	Class	0.22	1.71	0.22	1.07
Stillbirth paternal	Sb-p	%	2.50	4.00	2.50	3.45
Stillbirth maternal	Sb-m	%	2.50	4.00	2.50	3.45
Somatic cell count	SCC	s_A	1.00	14.53	1.00	14.53

Table 2. **Phenotypic correlations (upper triangle), genetic correlations (lower triangle) and heritabilities (diagonal elements) of the traits in the total merit index**

	Trait	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Fat	**0.30**	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Protein	*0.85*	**0.28**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Dg	*0.15*	*0.15*	**0.25**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Dp	*-0.15*	*-0.15*	*-0.05*	**0.40**	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	EUROP	*-0.05*	*-0.05*	*0.05*	*0.55*	**0.15**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Long	*-0.10*	*-0.10*	*0.00*	*-0.10*	*-0.10*	**0.10**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Pers	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.20*	**0.15**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Fert-p	*-0.10*	*-0.10*	*0.00*	*-0.10*	*-0.10*	*0.10*	*0.20*	**0.02**	0.00	0.00	0.00	0.00	0.00	0.00
9	Fert-m	*-0.20*	*-0.20*	*0.00*	*-0.10*	*-0.10*	*0.10*	*0.20*	*0.00*	**0.02**	0.00	0.00	0.00	0.00	0.00
10	Ce-p	*-0.10*	*-0.10*	*-0.10*	*-0.10*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	**0.05**	0.00	0.15	0.00	0.00
11	Ce-m	*0.10*	*0.10*	*0.10*	*0.00*	*0.00*	*0.15*	*0.00*	*0.00*	*0.00*	*-0.10*	**0.05**	0.00	0.15	0.00
12	Sb-p	*0.00*	*0.00*	*-0.10*	*-0.10*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.80*	*0.00*	**0.05**	0.00	0.00
13	Sb-m	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.15*	*0.00*	*0.00*	*0.00*	*0.00*	*0.80*	*-0.10*	**0.05**	0.00
14	SCC	*-0.25*	*-0.25*	*0.00*	*0.00*	*0.00*	*0.10*	*0.10*	*0.10*	*0.10*	*0.00*	*0.00*	*0.00*	*0.00*	**0.14**

2.3 Inclusion of conformation the index

Conformation as indicator for longevity

Breeding values for functional longevity are currently estimated in Austria by a non-linear Cox model accounting for censored records (Danner *et al*., 1993). Therefore longevity is already in the index and extension to include a conformation trait for early prediction of longevity includes only definition of an extra trait that does not have an economic weight but will improve prediction through correlation.

To check the efficiency of such an approach we include a single conformation trait that is assumed to be a combination of traits related to longevity in the index. The trait has a heritability of 0.36 (Brotherstone *et al*., 1998) and is assumed to be correlated only with longevity. As no reliable correlations between conformation and longevity are available due to reasons discussed later, two situations are considered. In one, the correlations are low (0.2 phenotypic, 0.3 genetic), in the second they are higher (0.3 phenotypic, 0.6 genetic). Both situations assume an environmental correlation of 0.3, the heritability for longevity is 0.1 as given in Table 2. The information for conformation in the selection index is based on 40 offspring of a bull. Two generations of pedigree are included when defining the information available for different selection groups.

Conformation as independent selection criterion

Here we include one conformation trait in the index with an assumed economic weight that is proportionate to the sum of the economic weights (scaled to genetic standard deviations) of all traits described in Table 1. The heritability is again 0.36 but this trait, which might be envisaged as some total score independent of whether traits are positively related with longevity or not, is assumed to be uncorrelated with all other traits in the index. Therefore, conformation is an independent selection criterion and the effects of selection on conformation in addition to selection for the index can be studied. Variations with up to 50 percent of the index weight being reserved for conformation are considered.

3 Results and discussion

Conformation as indicator for longevity

The effects of including a composite conformation trait as an indicator for longevity are presented in Table 3.

Assuming a genetic correlation of 0.3 between the conformation trait and longevity, the total monetary response per year is virtually unaffected in both breeds. Also the additional gain in longevity is very limited. Even when the correlation is 0.6, the increase in monetary gain is very small for Simmental (0.3 percent) and somewhat larger for Brown Swiss (2.2 percent). Correspondingly, the increase in natural gain for longevity is bigger in Brown Swiss than in Simmental. The reason for the difference in the results for Simmental and Brown Swiss is probably the use of proven bulls from other countries. For the Brown Swiss population it is assumed that 30 percent of of all inseminations are carried out with foreign bulls for which only INTERBULL breeding values for dairy traits are available (Egger-Danner *et al*., 1999). This means that there is no direct information on longevity for those bulls. For Simmental this is different because most of the inseminations with foreign sperm are done with bulls from Bavaria. For those bulls the information available is similar to the information on Austrian bulls.

Prediction of longevity from type traits is often advocated because direct information on this trait comes so late in life. Brotherstone *et al*. (1998) and Jairath *et al.* (1998) provide recent accounts of this notion. Brotherstone *et al.* (1998) estimated a genetic correlation of 0.52

between a phenotypic index of three conformation traits (foot angle, udder depth, teat length) and lifespan, a measure of longevity corrected for first lactation milk production. Jairath *et al.* (1998) estimated a correlation of 0.37 between estimated transmitting abilities for functional herdlife and an index of conformation traits including capacity, feet and legs, mammary and rump. Such correlation estimates are likely to be to high because they neglect the fact that type is often a culling criterion in its own right not related to the functionality of a cow (Brotherstone *et al*., 1998).

Of course the results depend much on assumptions like accuracy of estimates for the various breeding values estimations but the general conclusion of little increase in total merit is probably correct. The correlation between conformation and longevity of 0.6 is definitely the upper limit.

Pasman and Reinhardt (1999) come to the conclusion that the efficiency of conformation as early indicator for longevity is very limited when direct evaluation of longevity using survival methods is available. This is supported by the present study.

Conformation as an independent selection criterion

Figures 1 (for Simmental) and 2 (for Brown Swiss) give the loss in annual monetary response when putting weights between 0 and 50 percent of the total weight of the index on conformation. Loss in monetary response is marginal (1 percent) for a weight of 5 percent on conformation, is around 4 percent for a relative weight of 10 percent and 32 percent for a weight of 30 percent. For the extreme situation of putting half the weight in an index on conformation, the monetary response from the economically important traits is only around 40 percent compared to the base situation without selection for conformation.

In a questionnaire, Austrian farmers were asked to give subjective weights of dairy vs. beef vs. functional vs. conformation traits. Of 17,525 Simmental breeders, 7,137 answered this question and the average proportions given were 44:22:19:15. This means that farmers subjectively place a weight of 15 percent on conformation. Although this is definitely not comparable with an economic weight, it gives some indication of the importance of conformation to farmers. It is also arguable whether the farmer thinks about the part of conformation related to fitness or about the “beauty” of a cow when he is placing this subjective weight.

In other populations conformation is included in the total merit index. As an example, in German Holstein Friesian the following formula is currently used for calculation of the total merit index (RZG):

$$RZG = 100 + 0.88 \cdot \text{dairy} + 0.36 \cdot \text{conformation} + 0.22 \cdot \text{cell score} + 0.16 \cdot \text{functional traits}$$

where all subindices are expressed on the same (genetic) scale. This implies that conformation is getting about 22 percent of the total weight in the index. Using the results from Figure 2 this would mean about 17 percent reduction in monetary response, assuming the real economic value of conformation is zero.

Table 3. **Changes in total monetary gain per year from the total merit index and in natural gain for longevity (measured in genetic standard deviations, s_{A}, per year) when including conformation into the total merit index**

Inclusion conformation	Monetary gain, EUR	Gain longevity, s_A
Simmental		
not included	11.886	0.0508
included, r_g=0.3	11.893	0.0514
included, r_g=0.6	11.928	0.0543
Brown Swiss		
not included	9.577	0.0337
included, r_g=0.3	9.616	0.0378
included, r_g=0.6	9.789	0.0504

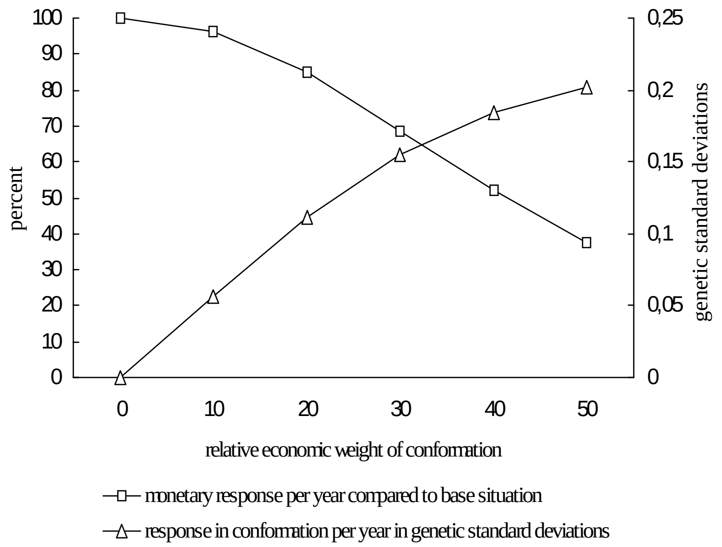

Figure 1. **Effect of independent selection for conformation on total monetary response from all other traits in the selection index (results for Simmental)**

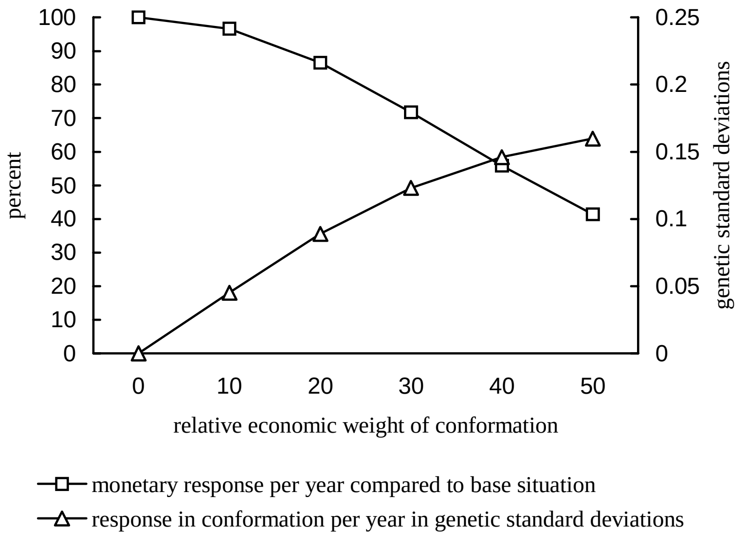

Figure 2. **The effect of independent selection for conformation on total monetary response from all other traits in the selection index (results for Brown Swiss)**

5 Conclusions

Inclusion of conformation traits into a total merit index as early predictors of longevity increases total merit only marginally. Independent selection for conformation as an expression of the "beauty" of cows can be detrimental if the relative weights put on conformation are to high.

References

Amer, P.R., Kaufmann, A., Künzi, N., 1994. Implications for farmers and political institutions from a Swiss cattle farm model. 3rd International Livestock Farming System Symposium, Aberdeen, September, 1-2.

Brotherstone, S., Veerkamp, R.F., Hill, W.G. 1998. Predicting breeding values for herd life of Holstein Friesian dairy cattle from lifespan and type. Anim. Sci., 67: 405-411.

Danner, C. Sölkner, J., Essl, A., 1993. Prediction of breeding values for longevity: comparison of proportional hazards analysis for culling rate and BLUP for stayability. Paper presented at the 44th Annual Meeting of the European Association for Animal Production (EAAP), August 16-19.

Egger-Danner, C.,Willam, A., Sölkner, J., Gierzinger, E., 1999. Optimisation of progeny testing schemes when functional traits play an important role in the total merit index. Proceedings International Workshop on Genetic Improvement of Functional Traits in cattle (GIFT) - Breeding goals and Selection Schemes, Wageningen. INTERBULL BULLETIN, 187-193

Hill, W.G., 1974. Prediction and evaluation of response to selection with overlapping generations. Anim. Prod., 18: 117-139.

Jairath, L., Dekkers, J. C. M., Schaeffer, L. R. Liu, Z., Burnside E.B., Kolstad, B., 1998. Genetic evaluation for herd life in Canada. J. Dairy Sci. 81: 550-562.

Karras, K., Niebel, E., Graser, H.-U., Bartenschlager, H., Nitter, G., 1994. ZPLAN – PC program to optimize livestock selection programs. User's Guide for ZPLAN, Version November 1994, University Hohenheim.

McClintock, A.E., Cunningham, E.P., 1974. Selection in dual purpose cattle populations: Defining the breeding objective. Anim. Prod., 18: 237-247.

Miesenberger, J., 1997. Zuchtzieldefinition und Indexselektion für die österreichische Rinderzucht. Dissertation. University of Agricultural Sciences, Vienna.

Miesenberger, J., Sölkner, J., Essl, A., 1998. Economic weights for fertility and reproduction traits relative to other traits and effects of including functional traits into a total merit index. Proceedings International Workshop on Genetic Improvement of Functional Traits in cattle (GIFT) - Fertility, Grub. INTERBULL Bulletin 18: 78-84.

Pasman, E., Reinhardt, F. 1999. Genetic relationships between type composites and length of productive life of Black-and-White Holstein cattle in Germany. Proceedings International Workshop on Genetic Improvement of Functional Traits in cattle (GIFT), Jouy-en-Josas. INTERBULL Bulletin 21: 117-121.

Philipsson, J., Banos, G., Arnason, T., 1994. Present and future uses of selection index methodology in dairy cattle. J. Dairy Sci., 77: 3252-3261.

Sölkner, J., Miesenberger, J., Willam, A., Fuerst, C., Baumung, R, 1999. Total merit indices in dual purpose cattle. Proc. 50th Annual Meeting of the European Association for Animal Production (EAAP), August 23-26, Zürich, Switzerland.