Genetic relationships between type composites and length of productive life of Black-and-White Holstein Cattle in Germany

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Abstract

Survival analysis made it possible to include records of cows alive in the breeding evaluation. However, estimated breeding values (EBV) of sires for length of productive life (LPL) still become reliable considerably later than EBVs for other traits of the same sire. EBVs for type traits can be used as early indicators for the EBV of LPL. Especially, composite indexes of type trait EBVs could be helpful for this purpose. First, it is attempted to predict the EBV for LPL from existing composite indexes. The correlation between predicted and actual EBV for LPL was only moderate. Correlations of composite indexes with EBV for LPL were at best slightly higher than the highest correlations of single type traits building these indexes. The composite index for body even had a negative correlation with EBV for LPL. Therefore, it is investigated how composite indexes could be redefined to predict EBVs for LPL better. Redefining the composite indexes resulted in indexes based on fewer traits and with higher correlations with EBVs for LPL. Prediction of EBV for LPL was only slightly improved. This was due to higher correlations among composite indexes after re-definition.

1. Introduction

Since 1998, breeding values for functional length-of-productive life (LPL) in Germany are estimated with the SURVIVAL-KIT V3.0 developed by Ducrocq and Sölkner (1994 & 1998). Survival analysis made it possible to include records of cows alive in the breeding evaluation. However, estimated breeding values (EBV) of sires for LPL still become reliable considerably later than EBVs for other traits of the same sire.

EBVs for type traits can be used as early indicators for the EBV of LPL provided type traits are defined clearly and scored accurately. Especially, composite indexes of type trait EBVs could be helpful for this purpose. So far, the composite indexes have been defined subjectively. It is attempted to predict the EBV for LPL from these composite indexes. It is also investigated how the composite index could be redefined to predict EBVs for LPL better. The study described here is the first part of a project, which should lead to the development of an estimation system for breeding values for LPL from direct EBVs for LPL and EBVs for type traits.

2. Material and methods

The data for this survey consists of EBVs for LPL of the test evaluation described by Pasman and Reinhardt (1999) and EBVs for type traits estimated in November 1998. RZN was considered as breeding value for LPL. RZN is a sire effect estimated by the SURVIVAL-KIT V3.0 (Ducrocq and Sölkner, 1994 & 1998) after standardization to a mean of 100 and a genetic standard deviation of 12, with higher values being more desirable (Pasman and Reinhardt, 1999). For estimation of type breeding values multitrait animal models within the trait-complexes body & dairy character, feet & legs, and udder were used. In these models, the fixed effects of classifier * year, herd * year * HF-percentage, age at first calving and stage of lactation were considered besides a random additive genetic effect (VIT, 1998). All EBVs were standardized to 100 ± 12 for the sires building the base (bulls born 1988 - 1990).

Genetic correlations between traits were derived by adjusting correlations between EBVs for reliabilities. First correlations between EBVs are estimated on a data set of all bulls with a reliability of the EBV for LPL of at least 90%. The genetic correlation was derived from the correlation between EBVs with (Calo et al., 1973):

$$r_g = r_{EBV,EBV'} * \sqrt{(\sum r_i^2 * \sum r_i^{2\prime})} / \sum(r_i^2 * r_i^{2\prime})$$

Indexes are routinely calculated for composite traits dairy character, body, feet & legs, and udder. Composite indexes generally are defined as:

100 + 0.75 * (Index of EBVs of linear traits within the trait complex)
+ 0.25 * (EBV of subjectively scored trait).

Linear type traits building the composite traits and their genetic correlations with LPL are presented in table 1.

Table 1: Linear type traits and their genetic correlations with LPL (n=593 sires)

Trait		Extremes		r_g with RZN
Dairy Character	DC	little	angular	0.01
Body Traits				
Stature	Sta	small	tall	0.01
Body Depth	BD	shallow	deep	-0.28
Strength	Str	narrow	wide	-0.18
Rump Angle	RA	ascending	sloped	-0.01
Rump Width	RW	narrow	wide	-0.16
Feet & Leg Traits				
Rear Leg Set Side View	LSS	straight	sickled	-0.10
Foot Angle	Ft	low	steep	0.20
Hock Quality	HO	swollen	dry	0.31
Rear Leg Set Rear View	LSR	toes out	parallel	0.18
Udder Traits				
Rear Udder Height	RUH	low	high	0.11
Suspensory Ligament	SL	weak	strong	0.15
Teat Placement	TP	wide	close	0.17
Fore Udder Attachment	FUA	loose	tight	0.34
Udder Depth	UDe	deep	shallow	0.41
Teat Length	TL	short	long	-0.12

The Index of linear traits (ILT) for dairy character consists of the EBV for angularity. ILTs for body, feet & legs, and udder are defined as:

$$ILT_{body} = 100 + 0.20*(EBV_{Sta}-100) + 0.25*(EBV_{BD}-100) + 0.20*(EBV_{RW}-100) - 0.20*(EBV_{RA}-100)^2/36 + 0.15*(EBV_{Str}-100)$$

$$ILT_{feet\&legs} = 100 + 0.30*(EBV_{Ft}-100) - 0.30*(EBV_{LSS}-100)^2/36 + 0.20*(EBV_{HO}-100) + 0.20*(EBV_{LSR}-100)$$

$$ILT_{udder} = 100 + 0.20*(EBV_{FUA}-100) + 0.20*(EBV_{RUH}-100) + 0.20*(EBV_{SL}-100) + 0.15*(EBV_{UDe}-100) - 0.15*((EBV_{TP}-(opt.^{**})^2)/36 - 0.10*(EBV_{TL}-100)$$

** The optimum area is from 100 to 112

ILTs and composite indexes are standardized to 100 ± 12 for the sires building the base (bulls born 1988 - 1990).

Linear and squared effects of the single traits building an ILT were considered when redefining composite indexes. Selection of traits was carried out with the RSQUARE procedure (SAS, 1985). Traits were selected on the basis of an R^2 adjusted for degrees of freedom within 0.005 of the maximum with a minimal number of traits. Factors for building the redefined composite indexes (RCI) were derived through linear regression. The squared effect of a type trait was dropped and the RSQUARE and linear regression procedures were repeated, when the regression factor for the squared effect suggested a minimum LPL for an average type breeding value, however, an intermediate optimum LPL was considered to be plausible.

Breeding values for indirect LPL (iLPL) were derived through a selection index of type composites weighted according to their genetic correlations with LPL. Generally, reliabilities of breeding values are considered in the selection index.

3. Results

Dairy character was not analysed further because angularity is the only trait defining the composite for dairy character. Therefore, an improvement of the relationship of dairy character could not be expected. Genetic correlations of the other official type composites among each other and with RZN are presented in table 2.

Table 2: Genetic correlations of the officialtype composites among each other and with LPL (n=593 sires)

	Body	Feet & Legs	Udder
LPL	-0.17	0.32	0.33
Body		0.13	0.20
Feet & Legs			0.45

The correlation between the direct EBV for LPL and the indirect EBV calculated with the composites for body, feet & legs and udder was 0.40 for the same sires. It is obvious from the negative genetic correlation between the composite for body and LPL that the composite index for body is not optimally predicting longevity. In the Netherlands stronger relationships of udder and feet and legs with LPL were found (Vollema, 1998). Jairath et al. (1998) also found a stringer relationship between udder and LPL based on Canadian data. From the correlations of linear udder traits with LPL, it is clear that the composite index for udder also is not predicting longevity optimally. The value of the genetic correlation for udder depth, which is one of the traits from which the index is derived, is higher than that of the index for udder (0.41). Estimated genetic correlations of udder depth with the indexes for body (0.04) and feet & legs (0.31) are lower than those of the index for udder. Replacing the index for udder with udder depth lead to a more accurate indirect EBV for LPL. The correlation between direct and indirect EBVs for LPL increased from 0.40 to 0.47.

The redefined indexes for body, feet & legs, and udder resulting from the analysis of the EBVs of 593 sires are:

$$RCI_{body} = 100 + 0.23*(EBV_{Sta}-100) - 0.92*(EBV_{BD}-100) - 0.25*(EBV_{RA}-100) + 0.50*(EBV_{RW}-100)^2/36 - 0.19*(EBV_{RW}-100)$$

$$RCI_{feet\&legs} = 100 + 0.22*(EBV_{Ft}-100) + 0.91*(EBV_{HO}-100) + 1.29*(EBV_{HO}-100)^2/36 + 0.26*(EBV_{LSR}-100)$$

$$RCI_{udder} = 100 - 0.17*(EBV_{TL}-100) + 0.97*(EBV_{UDe}-100).$$

Squared effects of two traits were included in the redefined composites; rump width^2 in the model for body and hock quality^2 in the model for feet & legs. For both, the estimate of the factor of squared effects was greater than zero. This suggested minimum RCI_{body} and $RCI_{feet\ \&\ legs}$ at intermediate relative breeding values for rump width and hock quality respectively. However, linear effects were included in the model too. Figure 1 shows values for RCI_{body} and $RCI_{feet\ \&\ legs}$ within a probable range of breeding values for rump width and hock quality.

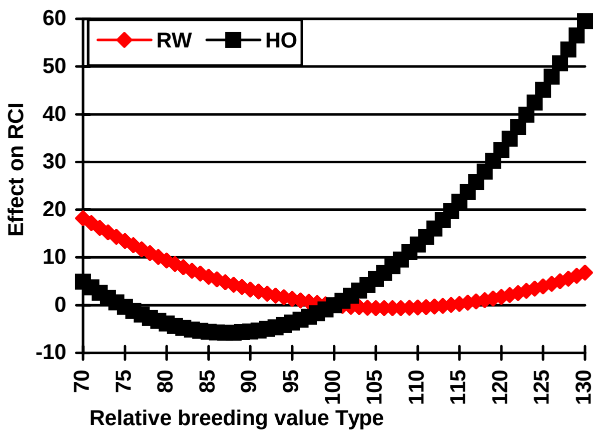

Figure 1: Effects of relative breeding valuesfor rump width and hock quality on the redefined composite indices for body and feet & legs

Squared effects of rump width and hock quality were considered in the model although minimum values for RCI_{body} and $RCI_{feet\ \&\ legs}$ were found within a probable range of breeding values for the linear traits. Reasons for this are that the minimum values did not occur very near to the average of the linear trait and increases in RCI to one side were much larger than increases in RCI to the other side.

Genetic correlations of the redefined composite indices among each other and with LPL are presented in table 3.

Table 3: Genetic correlations of the redefined type composites among each other and with LPL (n=593 sires)

	Body	Feet & Legs	Udder
LPL	0.31	0.42	0.42
Body		0.26	0.41
Feet & Legs			0.30

Genetic correlations of the redefined composite indexes with LPL were considerably higher than those of the official composite indexes. Especially, the improvement of the relationship between LPL and the composite index for body was considerable. However, genetic correlations of the composite index for body with other type composites also were higher after redefinition of the indexes. The correlation of the indirect breeding value for LPL calculated with the redefined composites indexes with the direct breeding value for LPL was 0.474. Reliabilities of the indirect breeding values for LPL were up to 24% for sires with many daughters in the evaluation for type traits.

Inclusion of direct LPL in the selection index resulted in a combined EBV based on direct LPL and type composites, which were highly correlated with the direct breeding values for LPL. The reason is that the weight for the EBV for direct LPL is high, except when the reliability of this EBV is extremely low. Furthermore, only small differences between reliabilities of EBVs for direct and combined LPL were observed when the reliability of the EBV for direct LPL was moderate.

Average RZN according to classes of the redefined composite indices for body, feet & legs, and udder are presented in tables 2, 3, an 4 respectively. Average RZN for the best classes of the RCIs is ca. 10 RZN-points (ca. 0.83 of a genetic standard deviation higher) than average RZN for the worst classes of the RCIs. The effect of RCI_{udder} on RZN appears to be larger than the effects of RCI_{body} and $RCI_{feet\&legs}$.

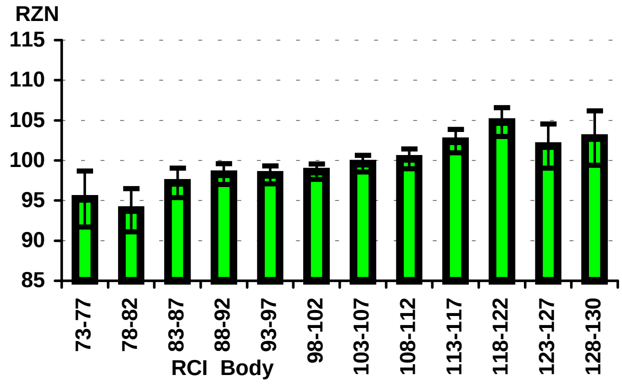

Figure 2: Average RZN for classes of RCI$_{body}$ with 95% confidence intervals (min. rel. 50%)

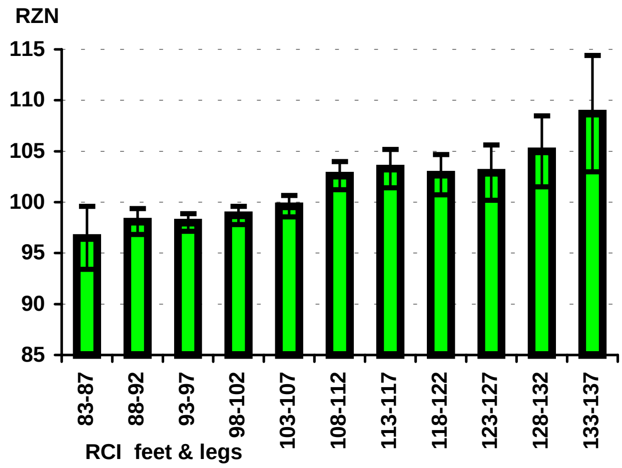

Figure 3: Average RZN for classes of RCI$_{feet\ \&\ legs}$ with 95% confidence intervals (min. rel. 50%)

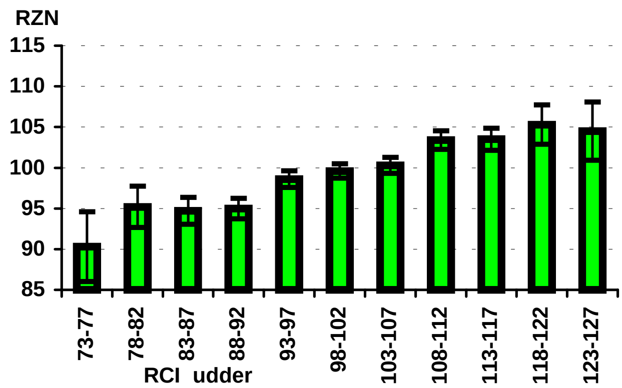

Figure 4: Average RZN for classes of RCI$_{udder}$ with 95% confidence intervals (min. rel. 50%)

4. Discussion

In this study, residual covariances among traits were ignored. The reason is that the residual effects for LPL estimated through survival analysis were not available. Larroque (1998) and Jairath et al. (1998) found the impact of ignoring residual covariances to be small. Although the breeding values for longevity used by Jairath et al. (1998) were not estimated with survival analysis, their conclusions on this may be valid for breeding values estimated with survival analysis too. The reason is that breeding values for LPL estimated with survival models and linear models on data without censored records are highly correlated (Vollema and Groen, 1998). Recalculating multivariate estimated breeding values for LPL, with weights changed by the maximum amount found by Jairath et al. (1998), resulted in very few recalculated combined EBVs differing more than 1.00 point on the RZN-scale (i.e. less than 0.1 genetic s.d.) from the combined EBVs calculated with the original weights. Jairath et al. (1998) found changes in weights due to including residual covariances to be dependent on the amount of daughter information. In this comparison it was not checked if the conditions for the weight changes applied.

Genetic correlations of linear traits building the body composite were less pronounced than in the study of Vollema (1998). The negative genetic correlations of body depth, strength, and rump width appear to be in line with the decreased LPL found for cows with larger bodies by Hansen et al. (1999). The correlation of foot angle with LPL was similar to that of claw diagonal found by Vollema. Weigel et al. (1998) and Larroque (1998), however, did not find many body or feet and legs traits with an absolute value of the correlation to longevity over 0.07. Only Weigel et al. (1998) reported a correlation between strength and longevity of similar magnitude as found in this study. Their results, however, are more difficult to compare with the results of this study because no adjustment was made for yield traits. Relationships of linear udder traits with LPL were generally slightly weaker than those found by Larroque (1998) and Weigel et al. (1998) and considerably weaker than those found by Vollema (1998). Exceptions were udder depth and fore udder attachment, where Weigel et al. found the lowest correlations. However, this may be due to the absence of adjustment for yield traits.

The genetic correlations of the redefined composite for body was higher than comparable correlations in Canada and the Netherlands (Jairath et al., 1998; Vollema, 1998). Redefinition of indices for feet and legs and udder had smaller effects. A stronger relationship with LPL still existed for feet and legs in the Netherlands and for udder in both countries.

Scoring of hock quality and rear leg set rear view first started recently (VIT, 1998). Therefore, breeding values of older sires for these traits were estimated through correlated traits. However, especially hock quality may be a useful trait because the correlations of hock quality with LPL was higher than the correlation of any of the other feet and legs traits.

The correlation of direct and indirect LPL appeared to be higher than the correlation found by Jairath et al. (1998) especially after redefining type composites. However, Jairath et al. considered all sires with published EBVs for type traits. The correlations of direct and indirect LPL based on all sires with published EBVs for type traits was lower in this study (only 0.26 with official type composites and 0.28 with redefined type composites).

It was shown in this study that re-definition of the composite indexes led to type composites with a closer relationship with LPL than the official German type composites. Application of the redefined composites led to a slight improvement of the predictability of LPL by type. The increase of the correlation between direct and indirect EBVs for LPL was smaller than would have been expected based on the increasing genetic correlations between type composites and LPL. The reason for this is that the genetic correlations among the redefined composite indices were considerably higher than the genetic correlations among the official type composites. Therefore, the maximum possible reliability of the selection index increased from ca. 21% to 24%. After inclusion of direct LPL in the selection index

The predictability of LPL by redefined composite indices than by official type composites is mainly due to the application of a better composite for udder. Most of the increase in the correlation between direct and indirect EBV for LPL was shown already by replacing the official composite udder by udder depth.

Prediction of LPL by type traits generally is poor. Only moderately correlated indirect breeding values can be obtained. The maximum reliabilities for indirect LPL are low (24%). The increase in reliability of the sire breeding values by additionally considering type traits is small, even when the reliability of the EBV for direct LPL is moderate. Better results might be achieved when including other traits in the indirect breeding value. Especially SCC and maternal fertility traits could be taken into account. The results of this study, however, may be useful for determination the importance of scoring the type traits considered in this study.

The sire index over all evaluated traits in Germany (RZG) published by VIT (1998) also considers type traits, SCC and maternal fertility. Type traits can be excluded from RZG when they are used in the estimation of a combined breeding value for LPL, because the only use of these traits is to predict LPL. Other traits, e.g. SCC, may have another influence on the overall genetic merit besides the indirect influence through LPL and therefore cannot be excluded from RZG. The genetic correlation between SCC and LPL and the weights of both traits, however, may have to be reconsidered.

This study is a first step to the development of a system for estimation of breeding values for LPL from direct and indirect information. MACE is preferred over selection index procedures for the estimation of the combined breeding values because in MACE genetic effects of relatives for type on an EBV for LPL of a sire can be considered. This would result in a more reliable estimation of combined LPL. However, selection index procedures were used in this preliminary study because weights on traits could be studied more easily.

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