Integration of Longevity into the Walloon Genetic Evaluation System

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Introduction

The objective of this paper was to present the results of the study that permitted to integrate longevity into global economic index and also to improve the type economic indexes used in Walloon Region of Belgium. In a first phase, genetic relationships between type traits (linear and synthetic) and direct longevity trait in a Holstein sire population were estimated. In a second phase correlations between direct longevity and current economic indexes were estimated and longevity was integrated into global economic index, which reflects expected lifetime economic profitability.

Materials and Methods

In this study, data were based on results from November 2005 routine run.

Longevity Evaluations

Since May 2005, a genetic evaluation system for direct longevity has been introduced in the Walloon Region of Belgium (Gengler *et al.*, 2005). Genetic evaluations of longevity were obtained from the lactation records that were used for the genetic evaluation of production extended to all known lactations of cows with at least a first lactation. Data consisted in 1,130,533 lactation records on 392,890 Holstein (at least 75% Holstein or Red-Holstein genes) cows. Genetic evaluations were submitted to INTERBULL for 436 sires. Results for 74,289 sires were obtained from INTERBULL.

Type Evaluations

Details of the type genetic evaluation system can be found in Croquet *et al.* (2006). Data included 90,782 type records with a maximum of 33 observed type traits from 81,491 Holstein cows. The genetic evaluation model used for type traits is a multi-trait repeatability model, using multiple diagonalization, missing values and heterogeneous variance adjustments. Genetic evaluations were submitted to INTERBULL for 497 sires. Results for 77,965 sires were obtained from INTERBULL.

Production and SCS Evaluations

Data for yields traits and SCS trait consisted of 13,469,906 test-day records from 767,795 cows. The model used in the genetic evaluation for production traits and SCS is a multi-lactations multi-traits random regression test-day model. More details are provided in Croquet *et al.* (2006). Results of these genetic evaluations were submitted to INTERBULL for 547 bulls and 508 bulls, for production and SCS respectively. INTERBULL returned 87,879 sires results for production and 80,172 sires results for SCS.

Post-Processing of INTERBULL Breeding Values

Results from INTERBULL type evaluations consisted of genetic breeding values of 16 linear traits and 3 synthetic traits evaluated by INTERBULL. Additional 14 type traits (9 linear and 5 synthetic) not processed by INTERBULL are used in the Walloon Region of Belgium. Theses values are predicted starting from the information transmitted by INTERBULL by using a selection index procedure (Weigel *et al*, 1998) using the (co)variances used in the regional genetic evaluation. Whenever Walloon results exist for these same traits, the breeding values were combined using a weighted average (Weigel *et al*, 1998). The results are similar to a pseudo-MACE (Multiple Across Country

Evaluation) for the traits not processed by INTERBULL, as international information is combined with information from the Walloon genetic evaluation system.

Current Partial and Global Economic indexes

A global economic index called **V€G** is used in Walloon Region. This global index is subdivided into three partial economic indexes: one for the milk production traits called **V€L**, one for the morphology traits called **V€T** and one for the functional traits called **V€F**. At this time, the V€L contains milk, fat and protein yields, the V€T contains the 19 type traits evaluated by INTERBULL, and the V€F contains only SCS. The V€T index is also subdivided in three second order partial economic indexes: one for the udder traits (**V€P**), one for the development and frame traits (**V€C**) and one for the feet and legs traits (**V€M**). Details of these indexes can be found in Croquet *et al.* (2006). These indexes, global and partial, should reflect a selection goal of economic profitability to life, as well as the components of this one.

Statistical analyses

In the first phase correlations between breeding values of longevity and breeding values of type traits were estimated, using as weight the reliability of longevity breeding value. These correlations were not exactly genetic correlations but should approximate genetic correlations in a similar fashion as proposed by Calo *et al.* (1973). The underlying assumption was that the correlations of breeding values that were known without error would yield correct genetic correlations. Obtained correlations were used to develop appropriate new relative weights for improved partial type economic indexes. This was done to avoid multicolinearity problems. Longevity was then combined with SCS to obtain a new V€F. Finally the final relative weight was obtained for all indexes by a revalidation step using multiple regressions.

Results and Discussion

Table 1 contains the approximated genetic correlations between longevity and type traits (linear and composite type traits). Positive impact on longevity is also presented in this Table 1.

The linear traits with the strongest effect on longevity were udder depth, bone quality, chest depth and body depth. Among the synthetic type traits, the highest impacts on longevity were found for traits related to udder system and for the feet and legs score.

Table 1. Approximated genetic correlations of linear and composite type traits with direct longevity.

Conformation trait	Correlation	Positive impact on longevity
Stature [I]	-0.02	*Shorter*
Chest width [I]	-0.15	*Narrower*
Body depth [I]	-0.20	*Shallower*
Chest depth	-0.21	*Shallower*
Loin strength	0.07	*Stronger*
Rump length	-0.04	*Shorter*
Rump angle [I]	0.12	*Lower*
Hips width	-0.13	*Narrower*
Rump width [I]	-0.13	*Narrower*
Foot angle [I]	0.01	*Steeper*
Rear leg set [I]	-0.08	*More curved*
Bone quality	0.21	*Flatter*
Rear leg rear view [I]	0.04	*Straighter*
Udder balance	0.18	*Higher rear*
Udder depth [I]	0.29	*Shallower*
Teat placement side	-0.08	*Shorter*
Udder support [I]	0.17	*Stronger*
Udder texture	0.09	*Softer*
Fore udder [I]	0.18	*Stronger*
Front teat placement [I]	0.11	*More inside*
Teat length [I]	-0.06	*Shorter*
Rear udder height [I]	0.14	*Higher*
Rear udder width	-0.04	*Narrower*
Rear teat placement [I]	0.09	*More inside*
Angularity [I]	-0.05	*Less angular*
Overall development	-0.12	*(-)*
Overall rump	-0.09	*(-)*
Feet and legs [I]	0.18	*(+)*
Overall udder score [I]	0.25	*(+)*
Overall fore udder	0.24	*(+)*
Overall rear udder	0.18	*(+)*
Dairy character	-0.02	*(-)*
Final conformation [I]	0.13	*(+)*

[I] INTERBULL trait

Jairath *et al.* (1998) found the same stronger relationships of udder and feet and legs with longevity based on Canadian data. Correlations between longevity and classical linear traits describing feet and legs were quiet low with values below 0.10. This is an indication that the non-linear nature of the optima of these traits limits their relationship with longevity. The synthetic feet and legs scores as defined in the Walloon Region integrate this non-linear nature (deviations from the optimum on a phenotypical level) and are therefore more correlated. Surprising was that bone quality had a clearly higher correlation with longevity even if the direct information was limited. However this result is in line with Schneider *et al.* (2003) who reported an important impact of this trait on length of productive life. Unfortunately bone quality is a trait that is not taken into account in many countries. A trait that was very disappointing was foot angle, however using data from other countries Powell and VanRaden (2003) reported similar results.

A smaller and less heavy animal seemed to have a better direct longevity than a taller and especially heavier animal. However final conformation score showed a positive correlation. According to these observations, a balanced morphological animal seems to have a greater longevity. In our system on a phenotypical level the most important non-body trait was udder (40%). For this reason we defined an udder corrected final conformation score.

These results confirmed that some type traits are good early factors to predict longevity as various authors suggested in their studies (Short and Lawlor, 1992, Dekkers *et al.*, 1994, Vollema and Groen, 1997).

Correlations between direct longevity and economic indexes (global and partial) were estimated in order to analyse their relationships with direct longevity. These correlations are presented in Table 2.

Table 2. Correlations of economic indexes and improved indexes with direct longevity.

Index: Global	Index: Partial	Index: Second order partial	Correlation	Correlation (improved indexes)
V€G			0.15	0.59
	V€L		0.05	0.06
	V€T		0.17	0.31
		V€P	0.27	0.27
		V€C	-0.11	0.25
		V€M	0.02	0.22
	V€F		0.30	0.98

Correlations were low between type economic indexes and longevity, excepted for V€P index, indicating that these indexes did not reflect correctly the field reality. So, composition of two of the three second order partial indexes (V€C and V€M) were reworked, in accordance with correlations between type traits and direct longevity (see Table 1) in order to be closer to the reality but also to express, through them, partly a contribution of type to the longevity.

Table 3. Definitions of economic indexes.

Index	Partial index / trait	Coefficient	Standard deviation	Relative importance in: Partial index	Relative importance in: V€G
V€G	V€L	1	96,21	48%	48%
	V€F	1	55,71	28%	28%
	V€T	1	48,30	24%	24%
V€L	Milk (kg)	-0,064	532	21%	10%
	Fat (kg)	1,75	17,70	19%	9%
	Protein (kg)	6,25	16,04	60%	29%
V€F	Somatic cell score	30,66	0,375	18%	5%
	longevity	277,93	0,185	82%	23%
V€T	V€M	1	21,19	36%	9%
	V€C	1	3,62	6%	1%
	V€P	1	33,84	58%	14%
V€M	Rear leg set	-4,11	1	16%	1,4%
	Rear leg rear view	2,06	1	8%	0,7%
	Bone quality	10,54	1	41%	3,7%
	Feet and legs	9,00	1	35%	3,2%
V€C	Overall development	-4,32	1	28%	0,3%
	udder corrected final conformation	11,11	1	72%	0,7%
V€P	Fore udder	8,64	1	14%	2 %
	Rear udder height	14,19	1	23%	3,2%
	Udder support	5,55	1	9%	1,3%
	Udder depth	14,19	1	23%	3,2%
	Front teat placement	2,47	1	4%	0,5%
	Rear teat placement	-11,11	1	18%	2,5%
	Teat length	-5,55	1	9%	1,3%
	** the udder corrected final conformation score was calculated as being final conformation score minus overall udder score*				
	Final conformation	*7,88*	*1*	*51%*	*0,5%*
	Overall udder	*-3,24*	*1*	*21%*	*0,2%*

Multiple regressions on the economic function of lifetime profitability had permitted to obtain coefficients/weights of these new indexes. In the same way, longevity was integrated into global economic index by a new definition of economic index for the functional traits that contained SCS and longevity information. Definitions of global and partial indexes are presented in Table 3 that gives a synthetic view of the relative importance of the indexes (all expressed in euros), of the traits, as well as the coefficients.

Genetic correlations of the improved economic indexes with direct longevity are also illustrated in Table 2.

Correlations between the improved type indexes and direct longevity were better, what lead to an improved V€T displaying a higher relationship with direct longevity. The improved V€T did not built only with type traits evaluated by INTERBULL. Indeed, some type traits not evaluated by INTERBULL but presenting a good approximated genetic correlation with direct longevity were taken into account in this index.
The improved V€F was highly correlated with direct longevity. The reasons are that the relative importance of longevity in this economic index is elevated and that genetic correlation between direct longevity and SCS is high (0.30).

The improvement of these different economic indexes led to a better correlation between the global economic index and direct longevity.

Correlations of the current economic indexes with the improved ones are illustrated in Table 4.

Table 4. Correlations between the current economic indexes and the improved economic indexes.

Indexes	Correlation with the improved one
V€G	0.85
V€L[1]	1.00
V€T	0.83
V€C	-0.43
V€M	0.51
V€P	1.00
V€F	0.48

[1] : Definition of V€L was modified independently from this study. The new weights reflect a change in the ratio fat/protein from 40/60 to 30/70.

The correlation for the global index (V€G) showed that the improved one will give a different arrangement of animals but similar to current V€G. The negative correlation for the body index, V€C, pointed to its new definition is totally different from the current one.

Conclusions

The estimated approximate genetic correlations showed that there are important relationships between type traits and direct longevity. These first results show the interest to study, more in details, links between type traits and longevity in order to develop combined longevity evaluations and to improve the current genetic evaluation system for longevity of the cows in our herds. Integration of longevity into the Walloon economic index system have permitted to review the type economic indexes and so to improve the global economic index in order to be closer to the reality in the field.

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