Selection index for bulls of Holstein cattle in the Czech Republic

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ABSTRACT: Complex selection indexes are proposed for bulls of Holstein cattle in the Czech Republic. Partial breeding values for milk performance, fertility and body conformation are combined in the index. Conformation is expressed either by linear classification or by general characteristics and body measurements. Variants according to the traits included in breeding objective and in performance recording were tested – breeding objective comprised milk, meat, milkability, health, reproduction, longevity; production traits and linear classification of body conformation or production traits and general characteristics of body conformation and/or production traits, and general characteristics of body conformation and body measurements were used as source of information (in performance recording). For practical use is recommended the variant of reduced selection index where milkability, health and meat performance were left out from breeding objective, and production traits and linear classification of body conformation were employed as a source of information. The index guarantees 69.30% reliability of breeding value estimate and the ratio of selection effects for milk, meat and secondary traits 78 : 8 : 14. The respective importance of milk performance in total (breeding values for milk and components) of reproduction and linear body classification as sources of information in the index are 79.61%, 15.52% and 4.86%.

Keywords: selection index; Holstein cattle; bulls; genetic gain; weights of traits; production; fertility; body conformation

Animals for breeding are always selected on a multi-trait basis. Although sometimes the breeder's intention is to change one trait only, changes in the complex of traits occur because the traits are mutually conditioned. Therefore selection index is used to evaluate the traits of animals important from breeding aspects in a complex way. Overall evaluation is given in monetary units and a change in each trait is expressed in monetary terms.

Currently, selection indexes are generally used in all species of farm animals. Several types of indexes exist for dairy cattle:

1. Indexes for selection of parents of successive generation.
2. Indexes for selection of the economically most fitting individuals (during their lifetime).
3. Partial indexes for groups of evaluated traits.

Known values of performance of these traits after adjustment for distorting effects of farm environment, i.e. breeding values, are a pre-condition for the evaluation of animals.

Hazel (1943) laid the foundations of the construction of selection indexes in animal breeding. Cunningham (1969, 1975) elaborated detailed methods for the construction of indexes to calculate relative weights of traits. An overview of the methods of index construction with constraints was presented by Brascamp (1984).

Population-genetic parameters and economic weights of traits are basic input parameters for the construction of indexes. Determination of these parameters is a permanent process because economic

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and breeding conditions are susceptible to changes and breeds undergo permanent development. Wolfová *et al*. (2001) determined the latest economic weights for Czech breeds of cattle. Genetic parameters of some traits were determined by Dědková and Wolf (2001) and Štípková *et al*. (2002a) recently.

Only data adjusted for effects of systematic environment can be combined in indexes. An estimate of breeding value is the best adjustment method. But variabilities of breeding values are different from those of measured performances. If breeding values for the particular traits are combined in the index, the method of index construction should be modified (Přibyl *et al*., 1988). The traits whose breeding values are estimated can be different from those that are to be improved. Therefore Schneeberger *et al*. (1992) modified the BLUP method: after this modification it is possible to include in the total genotype the traits that are not in production recording and whose breeding values cannot be determined directly. Estimated breeding value for each trait significantly depends on the volume of measured performances of the individual under observation and on the number of contemporaries, hence the same trait can have different weights in different individuals when included in the total index.

These difficulties can be overcome if it is possible to use a multi-trait animal model for all traits parallelly. It is not feasible for the time being with regard to the size of the evaluated population and the number of evaluated traits; breeding values must be determined separately for each trait or groups of traits that are subsequently combined in selection index. Several methods of combination of breeding values in total index were compared by Přibyl *et al*. (1997).

The method of construction of selection indexes for dairy cattle based on partial breeding values and their reliabilities was used by Přibyl (1994), Přibyl and Přibylová (1998) and Miesenberger (1997), whose dissertation was followed by further publications. The weight of traits in the index is influenced in the particular bulls by reliabilities of breeding values; this is the reason why the indexes are constructed for each bull separately by help of individual weighting coefficients.

Large effort is now in genetic evaluation of non-production traits. New results were presented in Interbull meetings (Bulletin No. 30 and No. 31, 2003).

Philipsson *et al*. (1993) investigated the principal importance of including reproduction and udder health traits into total merit index. The inclusion of functional traits in a total merit index tested Willam *et al*. (2002). The total merit index included dairy traits, beef traits and functional traits. The inclusion of functional traits in a total merit index has a positive effect on the annual monetary genetic gain. Experiences of including reproduction and health traits in Scandinavian dairy cattle breeding programmes described Philipsson and Lindhe (2003). Reproduction and health traits are of significant economic importance for dairy production.

Sölkner *et al*. (1999) were concerned with effect of conformation in total merit index. Conformation traits are considered to be early predictor of functional longevity. Miesenberger *et al*. (1998) indicated more then 10% higher selection response in a monetary units if total merit index with functional traits were used. Similar results reported Sörensen *et al*. (1999).

The economic performance of animals can differ across environments, mainly due to functional traits. In this case the genotype by environment interactions occur because of different economic weights in different environment. Visscher and Amer (1996) investigated the short term benefit of customising a total merit index for a fitness trait.

Philipsson *et al*. (1994) reviewed the construction of selection indexes for dairy cattle while Groen *et al*. (1997) summarised methodologies of determination of economic weights for indexes in cattle. The given state of methodology of selection indexes for dairy cattle was described by Sölkner and Fuerst (2002). Breeding values of bulls in various countries for the particular traits are currently combined in selection indexes in general although the way of combination is not always fully substantiated. Simplifications, when the weight of trait in the index is taken directly as the economic weight of this trait are used most frequently. Such simplification would be valid if a multi-trait animal model was used parallelly for all traits or when the reliability of breeding values of traits approaches 1. Berry *et al*. (2003) investigated that selection indices illustrate the possibility of continuous selection for increased milk production without any deleterious effects on fertility or body selection score. Efficiency of different selection indices for desired gain in reproduction and production traits investigated Kaushik and Khanna (2003).

An overview of some indexes used in different countries was presented in Interbull (2000) and by Stádník *et al*. (2002) and Šafus *et al*. (2002). Changes of country procedures for construction of selection indexes for dairy cattle presented Biffani *et al*. (2002), Rensing *et al*. (2002) and Pedersen *et al*. (2002).

Powel *et al*. (2003) analyzed selection intensities for groups of traits practiced in different countries.

The objective of this paper was to determine selection index for bulls of Holstein cattle on the basis of all available data.

MATERIAL AND METHODS

Breeding values (*BV*) of traits are combined in selection index through weighting coefficients (*b*).

$$I = b_1 . BV_1 + b_2 . BV_2 + \dots + b_n . BV_n \quad (1)$$

Total genotype (breeding objective) is expressed by the sum

$$H = a_1 . g_1 + a_2 . g_2 + \dots + a_m . g_m \quad (2)$$

where: a = economic weights of traits in breeding objective
g = unknown genetic values of traits in breeding objective

The most reliable prediction of total genotype (*H*) on the basis of index (*I*) can be made if the highest possible correlation exists between the index and total genotype. This correlation depends on the combination of weighting coefficients (*b*). The best combination is indicated by the solution of the equation system

$$b = P^{-1} . C . a \quad (3)$$

where: P = variance-covariance matrix of breeding values of the traits in performance testing
C = covariance matrix of breeding values of the traits in performance testing to the genetic values of traits in total genotype. Matrix (C) elements are

$$c_{jk} = r^2_{\mathrm{j}} . cov_{gjk} \quad (4)$$

where: r^2_{j} = reliability of the estimate of breeding value for trait (j)
cov_{gjk} = genetic covariance between trait (j) whose breeding value has been determined and trait (k) that is a part of total genotype

The reliability of total genotype prediction on the basis of index (r^2_I) is given by the ratio of index variance to total genotype variance

$$r^2_{\mathrm{I}} = (S^2_{\mathrm{I}})/(S^2_{\mathrm{H}}) \quad (5)$$

where: S^2_{I} = index variance given by the above-mentioned matrix (P) and determined weighting coefficients (b)

$$S^2_I = b` . P . b \quad (6)$$

S^2_H = variance of total genotype given by the genetic variance-covariance matrix of total genotype (G) and vector of economic weights (a)

$$S^2_H = a` . G . a \quad (7)$$

The prediction of expected genetic gain in trait (k) of the total genotype at unit selection intensity according index is expressed by the equation

$$\Delta_k = (b` . C_k)/S_I \quad (8)$$

where: Δ_k = expected value of genetic gain in trait (k)
C_k = k-th column of matrix (C)
S_I = standard deviation of the index ensuing from prescription (6)

Total genetic gain of all traits in the genotype is expressed in monetary terms. It is calculated as the weighted total of genetic gains for the particular traits multiplied by their economic weights.

The importance of trait in the total genotype (breeding objective) is given by its share in total genetic gain.

The importance of trait in the selection index (source of information) is determined as a percentage change in total genetic gain while this trait is left out from the index.

Input data for the calculation of weighting coefficients (*b*) are economic weights of traits, genetic standard deviations and genetic correlations, standard deviations of breeding values and correlations between breeding values and reliabilities of estimates of breeding values for the particular traits.

Traits in the total genotype (breeding objective) in Table 1 can be classified to several groups – milk, health, reproduction, earliness/longevity, meat, fitness to technologies. Economic weights with prospect to the future were taken over from Wolfová *et al*. (2001) and Wolfová (2003 – personal communication) and complemented for other missing data on the basis of comparison with literature data and own study. They are summarised in Table 1.

Similarly, population-genetic parameters were taken over from the latest available sources (Přibyl, 1994; Šafus *et al*., 1998; Bouška *et al*., 1999; Dědková and Wolf, 2001; Stádník *et al*., 2002; Štípková *et al*., 2002a).

Traits in performance testing in Table 2 comprise milk, reproduction, linear classification of body conformation, general characteristics of conformation and body measurements – data for which breeding values are determined. The table shows standard deviations of breeding values that were calculated using the current databank of bulls of Holstein cattle. 961 bulls born 1985–1998, tested within country, for which breeding values of all considered traits are known were used for study.

Reliabilities of breeding value estimates given in Table 2 were derived by an analysis of the volume of information available for bulls in the current national database (Štípková *et al*., 2002b).

Variants of indexes. Weighting coefficients of traits to be included in indexes and subsequent calculations are determined in several variants according to traits comprised in the breeding objective and traits in performance testing.

Breeding objective – total genotype:

A. All traits according to Table 1.

B. Traits except milkability (4), health (5, 6) and meat performance (18–22).

Table 1. Breeding objective (total genotype)

	Trait	Group of traits	Unit	EW	S_g	EW × S_g	PTG A	PTG B
1	Milk plasma	milk	kg	–1.13*	501.00	–566.13	–76.73	–176.18
1	Fat			13.12*	21.06	276.31	32.38	64.25
3	Proteins			93.62*	15.61	1 461.41	48.86	89.77
4	Milkability	technology	kg/min	700.00	0.20	140.00	6.81	
5	Mastitis	health	%	–19.00	7.50	–142.50	0.35	
6	Metabolic disorders			–30.00	4.00	–120.00	3.20	
7	Calving interval – direct effect	reproduction	day	–39.00*	7.00	–273.00	–4.03	–12.80
8	Calving interval – maternal effect			–23.13*	7.00	–161.91	–1.68	–3.97
9	Oestrus return in heifers – direct effect			–19.00*	5.50	–104.50	–1.96	–5.89
10	Oestrus return in heifers – maternal effect			–17.86*	5.50	–98.23	–1.18	–3.19
11	Calving – direct effect		0.01 of class	–66.00	0.022	–1.45	0.03	0.10
12	Calving – maternal effect			–33.00	0.013	–0.43	0.02	0.04
13	Stillbirths – direct effect		%	–200.00	2.50	–500.00	14.06	41.19
14	Stillbirths – maternal effect			–100.00	2.00	–200.00	7.11	12.20
15	Age at 1st calving	earliness/ longevity	day	–7.00*	30.00	–210.00	–0.50	1.86
16	Longevity		lactation	1 000*	0.65	650.00	41.69	93.87
17	Weight of cows	technology/ nutrition	kg	–10.00*	17.50	–175.00	–6.24	–1.26
18	Net gain	meat	g/day	9.76*	40.00	390.40	21.47	
19	Dressing classification		%	160.10*	0.20	32.02	0.35	
20	EUROP conformation		0.01 of class	–5.19*	0.50	–2.60	0.05	
21	Fattiness			–1.08*	0.30	–0.32	0.01	
22	Nutrient consumption		MJ, NE kg gain	–163.40*	1.50	–245.10	15.94	

EW = economic weights

S_g = genetic standard deviations

PTG A = proportions of traits in the variability of total genotype A

PTG B = proportions of traits in the variability of total genotype B

*economic weights taken over from Wolfová *et al*. (2001) and Wolfová (2003 – personal communication)

Performance testing – index:

1. Production traits according Table 2 (1–5) and linear classification of conformation (6–19).

2. Production traits and general characteristics of conformation (20–24).

3. Production traits, general characteristics of conformation (20–24) and body measurements (25–27).

RESULTS AND DISCUSSION

Table 1 shows economic weights (EW) of traits in the breeding objective, genetic standard deviations (S_g) and EW to standard deviation (EW × S_g). PTG A and PTG B are % proportions of traits in the variability of total genotype that comprises all traits. These proportions are calculated as a changes in the variance of total genotype S^2_H (equation 7) while a relevant traits are left out. Milk plasma (–77%) and amount of milk proteins (49%) account for the highest proportions in absolute terms. Compared to EW × S_g, the latter value is more exact because it comprises covariances. Sölkner and Fuerst (2002) also expressed the importance of traits by the ratio of variances.

Breeding values are combined in the selection index. As reported by Přibyl *et al.* (1997), the weight

Table 2. Performance testing (source of information)

	Trait	Unit	S_{BV}	r^2	S_g
1	Milk	kg	410.93	85	445.71
2	Fat content	%	0.20	83	0.22
3	Protein content	%	0.08	83	0.09
4	Own fertility (direct)	index	2.79	90	2.94
5	Fertility of daughters (maternal)	index	1.30	53	1.79
6	Angularity	scores	3.16	60	4.08
7	Stature		3.24	60	4.18
8	Chest width		3.28	60	4.24
9	Body depth		3.57	60	4.60
10	Rump angle		3.51	60	4.53
11	Rump width		3.43	60	4.43
12	Rear legs		3.40	60	4.38
13	Foot angle		3.56	60	4.59
14	Fore udder attachment		3.61	60	4.65
15	Rear udder height		3.45	60	4.45
16	Central ligament		3.50	60	4.52
17	Udder depth		3.43	60	4.43
18	Front teats placement		3.51	60	4.52
19	Teat length		3.50	60	4.51
20	Dairy character	scores	0.78	60	1.00
21	Capacity		1.29	60	1.66
22	Hip bones		1.33	60	1.71
23	Feet and legs		1.53	60	1.98
24	Udder		1.17	60	1.50
25	Height in hips	cm	1.19	60	1.53
26	Chest girth		1.37	60	1.77
27	Height in withers		1.24	60	1.59

S_{BV} = standard deviations of breeding values
r^2 = reliabilities of breeding values
Sg = genetic standard deviations

Table 3. Importance of traits in performance testing (%)

Trait	Unit	1A		2A		3A		1B		2B		3B	
Milk	kg	49.42		48.06		46.35		46.05		46.37		41.01	
Fat content	%	2.10	80.95	2.51	81.61	2.41	79.27	0.74	79.61	1.15	80.53	1.20	74.17
Protein content		29.43		31.04		30.80		32.82		33.01		31.96	
Own fertility	index	5.10	15.99	4.89	17.80	5.72	18.09	4.42	15.52	4.41	17.73	4.94	18.69
Fertility of daughters		10.89		12.91		12.37		11.10		13.32		13.75	
Angularity		0.04						0.37					
Stature		0.16						0.30					
Chest width		0.16						0.55					
Body depth		0.01						0.21					
Rump angle		0.21						0.59					
Rump width		0.08						0.16					
Rear legs	scores	0.71	3.06					0.49	4.86				
Foot angle		0.23						0.47					
Fore udder attachment		0.86						1.06					
Rear udder height		0.26						0.09					
Central ligament		0.03						0.07					
Udder depth		0.25						0.39					
Front teats placement		0.02						0.09					
Teat length		0.04						0.02					
Dairy character				0.04		0.04				0.21		1.04	
Capacity				0		0.48				1.22		3.12	
Hip bones	scores			0.34	0.58	0.45	1.44			0.24	1.74	0.09	4.31
Feet and legs				0.19		0.46				0.04		0	
Udder				0.01		0.01				0.03		0.06	
Height in hips						0.54						0.08	
Chest girth	cm					0.42	1.19					2.56	2.85
Height in withers						0.23						0.21	

of trait in the index is related to reliability of breeding value. Table 2 shows genetic standard deviations (S_g), standard deviations (S_{BV}) and reliabilities (r^2) of breeding values. Reliabilities of traits described average situation in evaluated Holstein population. Values of reliabilities were derived with ideology of selection index according amount of information, number of contemporaries within herds and relationship structure. For this reason all conformation traits are considered with the same reliability of 60%.

Usually not all traits of conformation are used in selection indexes. In our case breeding values for 14 traits of linear scoring of conformation are known. They are mutually correlated and serve for indirect selection for economically important traits in selection goal (production and functional – secondary traits). Relatively great number of correlated traits in our index (source of information) can overcome the random mistake of some input parameters and improve the total reliability of index. Also Rönningen (1974) indicated higher stability of indexes with more traits, when error for economic weights of one trait of 50% reduce the efficiency of index only for 2%.

Majority of conformation traits has from the standpoint of farmer some optimum between

Table 4. Relative weights of breeding values (BV) on standard deviation included in the index

Trait	Unit	1A	2A	3A	1B	2B	3B
Milk	kg	31.33	35.96	34.89	32.47	37.14	34.08
Fat content	%	7.00	8.30	7.38	4.44	5.89	5.67
Protein content		24.98	27.49	27.33	27.89	29.59	28.50
Own fertility	index	9.60	10.06	10.77	9.50	10.02	10.26
Fertility of daughters		14.41	16.64	15.74	15.46	17.69	16.97
Angularity	scores	–1.09			3.52		
Stature		2.25			–3.27		
Chest width		–2.45			–4.88		
Body depth		–0.75			–3.15		
Rump angle		2.01			3.58		
Rump width		1.29			1.96		
Rear legs		4.13			3.65		
Foot angle		2.36			3.57		
Fore udder attachment		4.82			5.65		
Rear udder height		2.53			1.59		
Central ligament		0.82			1.26		
Udder depth		–2.92			–3.93		
Front teats placement		0.59			1.40		
Teat length		–0.93			–0.73		
Dairy character	scores		1.23	1.28		2.80	6.67
Capacity			–0.15	–6.52		–5.95	–16.91
Hip bones			3.12	3.51		2.75	1.60
Feet and legs			–2.11	–3.44		–0.98	–0.18
Udder			–0.54	–0.62		1.06	1.28
Height in hips	cm			10.86			4.15
Chest girth				5.93			14.91
Height in withers				–7.11			–7.01

extremes. But today average production level of evaluated population requires that the average for traits should move to some direction. Therefore only linear selection indexes for directional selection are studied.

Not direct breeding value for longevity is available. For this reason only indirect selection for longevity is applied.

Index 1A

Importance of traits in performance testing are documented in Table 3. Milk yield (49.42%), protein content (29.43%) and fertility of daughters (10.89%) are sources of information with the highest importance in index 1A. The respective importance of milk performance in total, reproduction in total and linear classification in total are 80.95%, 15.99% and 3.06%. As for the body conformation, the importance of rear legs and fore udder attachment are highest.

Table 4 illustrates the relative weights of breeding values for traits on standard deviation to be combined in the index. The highest weighting coefficient was calculated for the breeding value of milk yield.

Table 5 shows overall data on the indexes. Reliability of index 1A is 65.93%. Total effect of selection is 76.37% in milk performance, 10.40% in meat performance and 13.23% in secondary functional traits. Genetic gain for the main production trait – amount of milk proteins at unit selection intensity – is 11.77 kg.

Table 6 documents genetic gains for all traits separately (Δ_k) and their proportions in total genetic gain in monetary terms (PROPMON). This proportion indicates importance of traits in the breeding objective. The amount of milk proteins (84%) has the highest importance in total genotype. The proportion of milk plasma in total genetic gain is negative (–22%), which is connected with the negative economic weight of this trait. Among the secondary traits the highest importance in breeding objective was determined for direct effect of calving interval (4%) and for longevity (5%). The importance of net gain taken separately is 6%.

Indexes 2A, 3A

The same production traits were included in all three indexes (1A, 2A, 3A). The indexes differ in the evaluation of body conformation when three methods were used: linear classification, general characteristics and body measurements. The methods are not independent of each other. Index 1A comprises a linear classification of body conformation, index 2A general characteristics of body conformation and index 3A involves general characteristics and body measurements.

Compared to index 1A, index 2A shows lower reliability (small difference) of the prediction of total breeding value (64%), slightly higher genetic gain in kg of milk proteins, and lower proportion for secondary traits (Table 5).

Index 3A is characterised by slightly lower reliability of the index than index 1A and higher than index 2A, while the proportions of selection effect are the similar to previous index. It is not quite correct that the body conformation is included twice in this index (general characteristics and body measurements).

The importance of traits in performance testing (Table 3) and genetic gains for traits (Table 6) are similar in both indexes.

Table 5. Reliability of indexes and selection effect in groups of traits

Index	Reliability r^2	Proportion in ΔG (%)			ΔG protein (kg)
		milk	meat	secondary traits	
1A	65.93	76.37	10.40	13.23	11.77
2A	64.01	78.06	10.48	11.46	11.90
3A	65.29	77.53	10.34	12.12	11.95
1B	69.30	77.66	8.48	13.85	11.87
2B	65.49	78.39	9.36	12.25	12.00
3B	67.91	78.18	7.20	14.62	11.87

Indexes B

The proportion of meat production in selection effect is generally low, and no sufficient data for direct selection are available in performance testing. Necessary data for direct selection for health are also missing in performance testing. First of all, selection is indirect, depending on the negative correlation to milk performance, which is a more than 50% source of information for this trait. It leads to contra-selection between these traits. Milkability is highly positively correlated with milk performance and negatively with udder health. Therefore animals with lower milk performance are preferred to for index selection from the aspect of udder health.

For the above-mentioned reasons simplified indexes were tested where the above mentioned groups of traits were left out from breeding objective. Selection effects are examined in all traits because they change due to correlations regardless of the selection aim.

The importance of traits in breeding objective partly changed in simplified indexes PTG B (Table 1). The importance of all traits left in breeding objective increased: the increase was highest in the indicators of milk performance – the proportion of trait in total genotype absolutely increased to –176 in milk plasma, 64 in fat and to 90 in milk proteins compared to –77, 32 and 49 in indexes A.

Changes in the importance of milk traits in performance testing occurred compared to indexes A (Table 3). Reliabilities of selection for there reduced indexes are higher than in indexes A (Table 5), and genetic gains for kg of milk proteins are also higher (indexes 1B and 2B). The proportions of selection effect for the groups of traits are maintained. Genetic gains for the particular traits are shown in Table 6.

Indexes are used in dairy cattle on a large scale. The representation of traits in selection indexes is very different. Main reasons for these differences are: it is necessary to take into account production conditions and breeding objectives of various populations; a possibility of employing the economic significance of investigated traits and characteristics through economic weights is also very important. Exist differences in the system of production recording. Another factor contributing to differences in the representation of traits in indexes is a possibility of selection either on the basis of direct available indicators or the application of their known relations and indirect selection for some of them. Detailed knowledge of relations between the investigated traits makes it possible to exclude mutually antagonistic indicators, hence selection indexes allow to use a balanced combination of traits and characteristics. In comparison of indexes there is to distinguish between traits included in selection goal and traits in selection index (source of information).

When Leitch (1994) compared selection indexes ten years ago, he stated that most European selection indexes ascribed negative index weight to milk yield in kg. The range of relative significance of the other indicators was large – type 1–50%, udder 37–100% of all type traits.

Powell (1995) analysed the used selection indexes and found out a high variability in weights of traits in selection indexes. The index weight of milk yield ranged from –0.004 to 0.055. Most indexes had negative values for milk yield with the exception of selection index used in the USA. Index weight for fat content was between 0.15 and 4.5. The highest variability was determined for the weight of protein content, 0.60 to 50.8. Fat content was included in the only index used in France.

Claus and Reinhardt (1996) analysed the use of different index weights of traits for selection of Holstein bulls in Germany. They reported these weights of traits in partial indexes: milk yield (–), milk fat (1), protein amount (4), fat procentuage (–), protein % (–), non-return test at 90 days (3), difficult calving (2), type (1) and udder (1).

As Van Doormaal *et al*. (2001) reported, Canadian selection index LPI (Lifetime Profit Index) was constructed to be aimed at production (60%) and at the traits of type (40%) connected with the maintenance of a high level of milk performance in following lactations. New LPI was introduced after adjustments in 2001. The adjustments accentuated these requirements:

– to maintain the relative ratio 60 : 40 between production and type/longevity
– to transfer the emphasis on protein content to fat content
– to include SCC (somatic cell counts) as an indicator of udder health

The existing index for Holstein cattle is constructed as follows: production 57% : survivability and resistance 38% : health 5%. Production traits involve only the amount of milk fat and proteins with relative weights 2.5 and 7.5. Resistance and

Table 6. Genetic gains – basic and simplified variants

Trait	1A		2A		3A		1B		2B		3B	
	Δ_k	PROP-MON	Δ_k	PROP-MON	Δ_k	PROP-MON	Δ_k	PROP-MON	Δ_k	PROP-MON	Δ_k	PROP-MON
Milk plasma	251.03	–21.63	257.38	–22.51	256.45	–22.21	254.97	–22.49	265.16	–23.50	259.66	–23.09
Fat	13.93	13.94	14.11	14.33	13.90	13.97	13.09	13.41	13.37	13.76	13.40	13.83
Proteins	11.77	84.06	11.90	86.24	11.95	85.77	11.87	86.75	12.00	88.14	11.87	87.43
Milkability	0.07	3.49	0.07	3.67	0.07	3.88	0.06	3.46	0.06	3.60	0.07	3.68
Mastitis	0.04	–0.06	0.13	–0.19	0.18	–0.27	0.22	–0.33	0.21	–0.31	0.21	–0.31
Metabolic disorders	1.08	–2.48	1.18	–2.75	1.22	–2.82	1.14	–2.67	1.12	–2.65	1.17	–2.76
Calving interval – direct effect	–1.41	4.20	–1.28	3.87	–1.63	4.88	–1.24	3.78	–1.23	3.79	–1.41	4.33
Calving interval – maternal effect	–1.23	2.18	–1.04	1.88	–1.14	2.03	–1.43	2.58	–1.12	2.04	–1.45	2.65
Oestrus return in heifers – direct effect	–0.82	1.18	–0.73	1.08	–0.97	1.41	–0.71	1.05	–0.71	1.07	–0.82	1.23
Oestrus return in heifers – maternal effect	–0.97	1.32	–0.82	1.14	–0.90	1.23	–1.12	1.56	–0.88	1.24	–1.14	1.61
Calving – direct effect	0.00	–0.01	0.00	–0.01	0.00	–0.01	0.00	0	0.00	–0.01	0.00	–0.01
Calving – maternal effect	–0.00	0	–0.00	0	–0.00	0	–0.00	0	–0.00	0.01	–0.00	0
Stillbirths – direct effect	0.03	–0.45	0.07	–1.02	0.11	–1.64	–0.05	0.77	0.06	–0.87	0.08	–1.24
Stillbirths – maternal effect	–0.25	1.90	–0.28	2.20	–0.27	2.09	–0.23	1.78	–0.29	2.29	–0.25	1.98
Age at 1st calving	5.18	–2.77	5.50	–2.98	5.46	–2.93	5.35	–2.92	4.86	–2.67	5.03	–2.77
Longevity	0.06	4.71	0.06	4.57	0.06	4.26	0.06	4.80	0.06	4.73	0.08	6.23
Weight of cows	–0.85	0.65	–0.24	0.19	0.39	–0.30	–3.20	2.50	–1.79	1.41	–1.48	1.17
Net gain	8.54	6.36	8.89	6.71	10.45	7.82	4.09	3.11	6.48	4.96	6.78	5.22
Dressing classification	0.02	0.21	0.02	0.21	0.02	0.21	0.01	0.16	0.01	0.14	0.01	0.18
EUROP conformation	–0.01	0.01	–0.02	0.01	–0.02	0.01	–0.02	0.01	–0.03	0.01	–0.02	0.01
Fattiness	–0.25	0	–0.01	0	–0.01	0	–0.02	0	–0.02	0	–0.02	0
Nutrient consumption	–0.25	3.18	–0.27	3.36	–0.21	2.61	–0.21	2.70	–0.22	2.83	–0.05	0.63

Δ_k = expected values of genetic gains
PROPMON = proportions in total genetic gain in monetary terms

survivability are evaluated mainly from the aspect of longevity. Specific traits in the index are at the ratio – herd lifetime (20%) : udder (40%) : legs (30%) : capacity (10%). These traits at a ratio 60% : 30% : 10% are included in the index from the health aspect: SCC, udder depth and milking rate (Van Doormaal *et al*., 2001).

Having evaluated the representation of traits in indexes used for dairy cattle, it is to state that traits of milk performance are included in 100% of indexes, meat production in 16% only, fitness in 38% and other traits (body conformation, milkability, temperament, etc.) in 56% of indexes (Šafus *et al*., 2002). Other marked differences are in the mutual ratio of fat content and protein content – the ratio is in the range from 1 : 1.5 to 1 : 11.3. The indicator of milk yield is not used in 50% of the examined indexes or it has a negative value in the other 50% of indexes (Šafus *et al*., 2002). Besides the traits from the sphere of production, milk and meat, the indicators of health, longevity, body conformation and type are increasingly used. The ratio of weights in indexes for performance and secondary traits highly fluctuates. But genetic gain is achieved still highest for production traits (Sölkner and Fuerst, 2002).

CONCLUSION

Indexes 1 have higher correlation wit selection goal and use breeding values directly for each linear scoring conformation traits. Indexes 2 used general characteristics for conformation (combinations of several characteristics not by genetically optimal way), which yields to some waste of information. Indexes 3 duplicated the conformation in indexes, which is methodically wrong. The difference between indexes 1, 2 and 3 are small. Indexes A include all traits in selection goal, in indexes B trait without direct production recording and strong negative correlation to milk productions are deleted from selection goal.

We recommend index 1B to be used, which does not comprise meat performance, milkability and health in the breeding objective and employs a linear classification of body conformation as a source of information. Linear classification is evaluated by Interbull and should the foreign sires be included in evaluation with selection indices, which is not possible for general characteristic of conformation.

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ABSTRAKT

Selekční index pro býky holštýnského skotu v České republice

Komplexní selekční indexy jsou navrženy pro býky holštýnského skotu v České republice. Do indexu jsou kombinovány dílčí plemenné hodnoty pro mléčnou užitkovost, plodnost a zevnějšek. Zevnějšek je zohledněn buď lineárním popisem, nebo souhrnnými charakteristikami a tělesnými mírami. Byly prověřeny varianty podle vlastností zahrnutých do selekčního cíle a do kontroly užitkovosti – v selekčním cíli byly zahrnuty buď všechny vlastnosti, nebo byla vypuštěna dojitelnost, zdravotní stav a masná užitkovost. V kontrole užitkovosti byly použity užitkové vlastnosti a lineární popis zevnějšku nebo užitkové vlastnosti a souhrnné charakteristiky zevnějšku, resp. užitkové vlastnosti a souhrnné charakteristiky zevnějšku a tělesné rozměry. Pro praktické použití byla vybrána varianta selekčního indexu, kde byly ze selekčního cíle vypuštěny dojitelnost, zdravotní stav a masná užitkovost a jako zdroj informací v kontrole užitkovosti byly použity užitkové vlastnosti a lineární popis zevnějšku. Index zaručuje 69,30% spolehlivost odhadu souhrnné plemenné hodnoty a podíl šlechtění na mléko, maso a druhotné vlastnosti v poměru 78 : 8 : 14. Jako zdroj informací v indexu má mléčná užitkovost souhrnně (plemenné hodnoty pro mléko a složky) význam 79,61 %, plodnost 15,52 % a zevnějšek 4,86 %.

Klíčová slova: selekční index; holštýnský skot; býci; genetický zisk; význam vlastností; produkce; plodnost; zevnějšek

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