SELECTION ON THE MAJOR COMPONENTS OF MILK TO MAXIMISE PROFIT IN DAIRY HERDS

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SUMMARY

The possibilities of modifing milk composition by breeding in dairy cattle were studied. Profit equation were used by calculating net economic value of milk components. Net economic values for milk, fat and protein yield were estimated to derive economic indices for the case of no milk quota. The net economic values for carrier and weighting factor for milk in the index were only positive when milk was paid for its volume. In all casses, genetic responses for milk, fat and protein were high. Introduction of a no payment for carrier in addition to a payment for fat and protein resulted in slightly higher response of the protein yield if the ratio of fat:protein was 1:3. In general, a selection based on economic indices for milk, fat and protein yield, is insensitive to a large range of real or expected prices for fat and protein.

Keywords: economic value, index weights, genetic progress.

INTRODUCTION

The callenge for a farmer to breed cattle is determined by the net economic value of one unit of milk, which is a weighted sum of the net economic values of the components carrier, fat and protein. Economic indices to select for milk components have been introduced in many countries. In Estonia, milk is paid for its carrier, fat and protein yield. The ratio of prices for carrier: fat: protein is about 1: 10: 25. In this paper, an assessment will be made of net economic values which should be used when aiming at maximum genetic change of milk components. Genetic responses for the milk components, based on an economic index selection will be examined for different prices and with no limitations of milk output per herd.

MATERIALS AND METHODS

Genetic parameters. Genetic parameters for 305-day milk production traits, required for selection-index computations, were estimated. The data comprised 305-day production records of Estonian Black and White heifers, which calved between 1990...95. The data were screened for lactation length (at least 260 days), age at calving (between 23 and 33 months), at least 10 paternal half-sibs. After screening 15 617 heifers with a complete lactation were left. In the statistical mixed model, used for estimation of variance components by a half-sib analysis, fixed effects for herds, months of calving, age at calving and random effects for sires were considered. The traits analyzed, were 305-day milk, carrier, fat and protein yield. Carrier was equal to milk yield minus (fat + protein yield). Estimated variance components between sires were based on records of young bulls only. Genetic relationships among sires were not considered. Variance and covariance components were estimated by Harvey (1990) program.

Genetic responses by use of net economic values. In a dairy enterprise the net economic value of one unit of extra milk per cow is of interest, which can be used in the breeding goal. Milk is a composition of carrier, fat and protein and farmer may receive different prices for different components. The aggregate genotype was defined as:

$$H = v_c g_c + v_f g_f + v_p g_p$$

where: g_c, g_f, g_p, genotypic values for carrier, fat and protein yield, respectively;
v_c, v_f, v_p, net economic values for carrier, fat and protein yield, respectively.

To derive net economic values, profit equations were used. The index was defined as:

$$I = b_1 BV_m + b_2 BV_f + b_3 BV_p$$

where: b_1, b_2, b_3, weighting factors;
BV_m, BV_f, BV_p, predicted breeding values for 305-day milk, fat and protein yield, respectively.

Index weights and genetic responses were derived by selection-index theory (Cunningham 1969; Brascamp 1989), using Selection Index Program (SIP) (Wagenaar et al. 1995). Selection on an index pertaning to H will maximize the monetary returns of selection for milk. Following Groen and Van Arendonk (1997), the net revenues of dairy farm is represented by the following profit equation:

$$P_{(1)} = p_c C + p_f F + p_p P + R_{ov} - \{(b_c C + b_f F + b_p P + Ma)K_v + K_{ov}\} =$$
$$= C(p_c - b_c K_v) + F(p_f - b_f K_v) + P(p_p - b_p K_v) + R_{ov} - Ma\, K_v - K_{ov} =$$
$$= C \times 0.978 + F \times 5.051 + P \times 22.480 - 4284.84$$

Net economic values for carrier, fat and protein were equal to the partial derivates divided by N of profit to C, F and P, respectively.

$$v_c = \frac{\partial P_{(1)}}{\partial C} = 0.978\,; \qquad v_f = \frac{\partial P_{(1)}}{\partial F} = 5.051\,; \qquad v_p = \frac{\partial P_{(1)}}{\partial P} = 22.480$$

Average herd production level, feed requirements, returns and costs to calculate the net economic values are given in Table 1.

Table 1. Values of the parameters to derive net economic weights of carrier, fat and protein

Average production of a cow (kg / year)		*Energy requirement (MJ ME/kg)*		*Prices*	
C- Carrier	5513	b_c- Carrier	1.3	p_c- Carrier (per kg)	1.07
F- Fat	249	b_f- Fat	69.9	p_f- Fat (per kg)	10
P- Protein	197	b_p- Protein	35.6	p_p- Protein (per kg)	25
		Ma- Maintenance and growth (per year)	46 156	K_v- Feed (per MJ ME)	0.0708
				R_{ov}- Other revenues (cow $^{-1}$ year $^{-1}$)	723
				K_{ov}- Other costs (cow $^{-1}$ year $^{-1}$)	1740

Milk production is not fixed per herd, therefore return prices for the milk components, feed requirements for production of the milk components and costs for concentrates are required to be known. Prices for milk should be valid for the moment the offspring of selected parents will produce. To study the sensitivity for variation in future circumstances, selection indices and genetic responses of the milk components were computed for a range of carrier: fat: protein price rations.

RESULTS AND DISCUSSION

Genetic parameters. Overall means, standard deviation and estimated genetic parameters are presented in Table 2.

Table 2. Estimated genetic and phenotypic parameters for 305-day production traits in first lactation of Estonian Black and White Cattle (h^2 on the diagonal; σ_p above and σ_g under the diagonal)

Component	Mean	Standard deviations		h^2, σ_p, σ_g		
		Genetic	Phenotypic	Carrier	Fat	Protein
Carrier	5513	365	587	0.287	0.790	0.924
Fat	249	12.6	23.3	0.826	0.349	0.864
Protein	197	10.6	19.4	0.890	0.858	0.293

Genetic responses with use of net economic values. Table 3 summarizes net economic values for carrier, fat and protein, selection index weights and genetic responses aiming a maximum genetic progress of returns from milk production.

The net economic values for carrier and weighting factor for milk in the index were only positive when milk was paid for its volume. When the payment for milk is based solely on the fat and protein yield, the net economic value of carrier is negative in all cases, because of the amount of lactose in carrier. If the payment for fat is equal to that for protein, then the net economic value of protein is higher than fat because of its lower feed requirements. In all cases, genetic responses for milk, fat and protein were high. If the carrier: fat: protein price was 0: 1: 3, genetic response was highest for protein yield. Correlation between aggregate genotype and index was 0.85. If the carrier: fat: protein price was 0: 1: 1, genetic response was highest for fat yield. Correlation between aggregate genotype and index was 0.85. If the carrier: fat: protein price was 1: 10: 25, genetic response was highest for milk yield. Correlation between aggregate genotype and index was 0.84. Introduction of a no payment for carrier in addition to a payment for fat and protein resulted in slightly higher response of the protein yield if the ratio of fat: protein was 1:3.

In general, a selection based on economic indices for milk, fat and protein yield, is insensitive to a large range of real or expected prices for fat and protein, which agreed well with the results of Wilmink (1988).

Table 3. Economic values for carrier, fat and protein yield and genetic responses (selection intensity = 1) per trait for the case of no milk quota

Payment schemes				
Ratio price carrier: fat: protein	1:10:25	0:1:1	0:1:2	0:1:3
Net economic values (EEK kg^{-1})				
Carrier	0.978	-0.092	-0.092	-0.092
Fat	5.051	13.050	7.051	4.051
Protein	22.480	15.480	21.480	24.480
Index weighting factors				
Milk	1.28	-0.1719	-0.2106	-0.2297
Fat	15.78	21.91	13.02	8.578
Protein	24.31	19.49	29.34	34.21
SD of the index	496	259	244	237
SD of aggregate genotype	590	304	287	281
Genetic progress (generation^{-1})				
Milk	256.8	229.2	230.2	228.9
Fat	10.7	11.5	11.0	10.7
Protein	8.5	8.4	8.7	8.8
Correlation between index and aggregate genotype	0.84	0.85	0.85	0.85

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