CATTLE BREEDING GOALS AND PRODUCTION CIRCUMSTANCES

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Introduction

The general goal in animal breeding is: obtaining a new generation of animals that will produce the desired products more efficiently under future farm economic and social circumstances than the present generation of animals (Politiek, 1962). In selecting females and males that will be used as parents of the next generation, major problem is the relative emphasis that is to be put on animal traits which influence the efficiency of production. Selection indexes (Hazel, 1943) provide possibilities for the definition of a concrete breeding goal (in terms of an aggregate genotype selected for by a correlated information index) that can be used directly in selecting parents. Genetic gain for the aggregate genotype is optimized by maximizing the correlation between aggregate genotype and index (Groen, 1989). Which traits should be included in the aggregate genotype, and index and the relative emphasis these traits will obtain, depends upon three aspects (Harris, 1970):

1. relative contribution of improvement of the trait to improvement of efficiency of production;
2. potential for genetic improvement of the trait (e.g. genetic variability);
3. costs of accurately estimating genetic merit of animals for the trait.

The relationship between breeding goal and production circumstances arises from the influences of production circumstances on natural circumstances, social circumstances and economic circumstances that determine the relative emphasis of animal traits within the (concrete) breeding goal (Groen, 1989). Published research results indicate that product prices are likely to influence relative contributions of the improvement of animal traits to economic efficiency of production. Different managerial practices may cause the standard deviations for traits to vary in different herds (Hazel, 1943). For example: average milk production levels influence levels of genetic and phenotypic variances (Mayala and Hanna, 1974). Knowledge on the relationship between breeding goal and production circumstances is important for (Groen, 1989):

1. an accurate definition of the breeding goal, giving optimum levels of economic revenues of the breeding programme, according to the future state of production circumstances;
2. an accurate calculation of the level of economic revenues of breeding programmes, in order to optimise the structure of the programme.

Efficiency of production

Efficiency of production is a function of inputs and outputs of the production system. Inputs can be defined as the total of production-factors required for production within the system; outputs as the total of products resulting from production within the system (Groen, 1989). Differences between biological and economic efficiency are restricted to differences in the way inputs and outputs are defined. In the biological definition, inputs and outputs are expressed in energy and/or protein terms (e.g. Aleandri et al., 1984); in the economic definition this is done in terms of money. The major problem arising with the biological definition is that not all inputs and outputs can be expressed in terms of energy and/or protein. The economic definition largely deals with that problem (Groen, 1989). A disadvantage of the economic expression instability in time and place of monetary units (Scholte, 1977). Notwithstanding imperfectness, money is "the standard for measuring value" (Stonier and Hague, 1964). Therefore, efficiency of production is considered to be economic efficiency, and the contribution of improvement of a trait to improvement of efficiency is called "economic value". Three possibilities to define efficiency function of the production systems are (Harris, 1970): 1) maximize profit (=outputs-inputs); 2) minimize costs per unit of product; 3) maximize revenues/costs. In defining breeding goals, definition of efficiency function has to correspond to the individual livestock producer's selection objectives (Harris, 1970). Breeding organisations should be concerned with the individual producer's interest, because the producer's primary reason to buy a certain breeding stock at a certain price, will be based upon his assessment of how animals will contribute to the efficiency of his farm (Harris, 1970). As the individual agricultural producer deals with the competitive market (no individual price setting), his interest will be profit maximisation rather than cost price minimisation (Stonier and Hague, 1964). According to Pearson (1986), in temperate zones breeding goals for intensive milk production have been developed for producers or groups of producers rather than for taxpayer-financed national programs and therefore, emphasis is put on profit maximisation. National governmental interests might be cost price minimisation. When breeding goals are focused on the individual producer's interest, a result may be reduced cost price. The objective for a farmer breeding dairy 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 that 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 on 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), and at least 10 paternal half-sibs. After screening 15 617 heifers with a complete lactation were left. In the mixed model, used for estimation of variance components by a half-sib analysis, fixed effects of herds, months of calving, age at calving and random effects of sires were considered. The traits analysed 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's program (Harvey, 1990).

Genetic responses by use of net economic values. In a dairy enterprise the net economic value of one unit of extra milk per cow can be used in the breeding goal. Milk is a combination of carrier, fat and protein and farmers 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 are the genotypic values for carrier, fat and protein yield, respectively;
v_c, v_f, v_p are the net economic values for carrier, fat and protein yield, respectively.

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 are weighting factors;
BV_m, BV_f, BV_p are 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 pertaining to H will maximize the monetary returns of selection for milk.

Following Groen and Van Arendonk (1997), the net revenue of a dairy farm is represented by the following profit equation:

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

The terms of profit equation are defined in Table 1.

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.

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. 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 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 by 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 by volume. When the payment for milk is based solely on the fat and protein yield, the net economic value of carrier was 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 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, a result which agrees well with those 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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Veiste aretuseesmärk ning tootmistingimused

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Kokkuvõte

Veiste aretusprogrammide koostamise eelduseks on aretuseesmärgi defineerimine ning tuleviku majandustingimuste arvestamine. Käesolevat uurimust tuleb käsitleda kui esimest etappi eesti mustakirjut tõugu veiste aretusprogrammide koostamisel selleks, et leida, milline on konkreetne tulu erinevatest aretusprogrammidest ning millised kombinatsioonid on rahalises väärtuses kõige paremad.

Antud etapis uuriti eesti mustakirju karja (n=15617) piimatoodangu näitajate, st. kandja = piimatoodang – (valgutoodang + rasvatoodang), rasva- ja valgutoodangu fenotüübilisi ja genotüübilisi parameetreid, päritavust, fenotüübilist ja genotüübilist standardhälvet (tabel 2). Kandja, rasva- ja valgutoodangu majanduslike väärtuste leidmiseks kasutati kasumivõrrandeid, mis võtsid arvesse kvoodivaba piimatootmise. Tootmisnäitajad ning piimatootmise energeetilised väärtused piimakomponentide lõikes on esitatud tabelis 1. Nii eelpool toodud piimatoodangu näitajate geneetilised parameetrid kui ka majanduslikud väärtused olid eelduseks geneetilise progressi leidmiseks selektsiooniindeksi programmi (SIP) abil piimakomponentide erinevate hinnasuhete korral (tabel 3). Esimene hinnasuhe on 1995. a. hindade alusel, järgnevad aga kirjeldavad geneetilisi muutusi, kui kandja-, rasva- ja valgutoodangu hinda muuta erinevates proportsioonides.

Nagu nähtub tabelis 3 esitatud tulemustest, on geneetiline progress generatsiooni kohta suur kõigi hinnakombinatsioonide korral, erinedes veidi komponentide lõikes. Korrelatsioonid kõigi hinnakombinatsioonide puhul agregaatgenotüübi ning indeksi vahel olid kõrged, mis näitab, et kasutatud aretusindeksid peegeldavad hästi aretuseesmärki.