GENETIC IMPROVEMENT OF PRODUCTION AND FUNCTIONAL TRAITS IN ESTONIAN HOLSTEIN POPULATION

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__KOKKUVÕTE. Eesti holsteini tõugu veiste produktsiooni- ja funktsionaalsete tunnuste geneetiline parandamine.__ Aretusväärtuse koondindeksi leidmiseks peab teadma aretuseesmärki (agregaatgenotüüpi) lülitatud tunnuste suhtelist majanduslikku kaalu. Eesti holsteini tõugu veiste majanduslikud kaalud (kasum, mis saadakse tunnuse parandamisel ühe standardühiku võrra) leiti kasumifunktsioonide osatuletistena, kasutades suletud karja bioökonoomilist mudelit. Kulude ja tulude diskonteerimisel kasutati 10%-list nivood. Piimatoodangu, rasva- ja valgusisalduse, ööpäevase massi-iibe, tapasaagise, nuumpullide söödaväärinduse ja netoiibe, poegimisvahemiku, esmaseemenduseaegse vanuse, mullikate esmaseemenduse ja tiinestava seemenduse vahelise intervalli ning lehmade kasutusea majanduslikud kaalud leiti piimakvoodi ning kvoodivaba piimatootmise tingimuse jaoks (tabelid 1 ja 2). Piimakvoot mõjutas pisut, kuid siiski mitte oluliselt piimatoodangu majanduslikku kaalu, kõige suurem oli mõju lehmade kasutuseale. Kõigile ülejäänud uuritud toodangu- ja funktsionaalsetele tunnustele mõju praktiliselt puudus. Kõige olulisemaks majanduslikku kaalu omavaks tunnuseks aretuseesmärgis oli piimatoodang, samal ajal kui teiste tunnuste majanduslikud kaalud moodustasid piimatoodangu majanduslikust kaalust ainult 3–8%. Ainult nuumpullide söödaväärindus moodustas piimatoodangu majanduslikust väärtusest 48% ning lehmade kasutusiga 22%. Diskonteeritud majandusliku kaalud olid madalama väärtusega kui diskonteerimata majanduslikud kaalud ning kõige suurem oli diskonteerimise mõju kõigist uuritud tunnustest just lehmade kasutuseale. Selektsiooniedu polnud piimakvoodist ega diskonteerimisest sõltuv, küll aga vähenes diskonteerimise tulemusena karja kogukasum 59%. Tulenevalt eeltoodust tuleks eesti holsteini tõugu veiste geneetiliseks parandamiseks aretuseesmärki lülitada kõige suuremat suhtelist majanduslikku kaalu omavad tunnused, milleks on lehmade piimatoodang, piimakomponentide sisaldus, intervall esimese ja tiinestava seemenduse vahel, lehmade kasutusiga ning nuumpullide söödaväärindus. Nimetatud tunnused peaksid olema aluseks veiste aretusindeksi koostamisel.

Abstract

For the derivation of economic weights, a bioeconomical model of a closed herd which included the whole integrated production system of dairy breed was used. The total discounted profit for herd was calculated as the difference between all revenues and costs that occurred during the whole life of animals born in the herd in one year and that was discounted to the birth year of these animals. Revenues and costs connected with one generation of progeny of selected parents were discounted with a discounting rate 10% to the birth date of the progeny. Economic weights of milk yield, fat and protein content, daily gain, dressing percentage, feed conversion and net daily gain in bulls, calving interval, age at first breeding, interval between the first and last breeding of heifers and cow longevity were estimated under assumed quota on the milk production with given fat and protein content and non quota conditions for the Estonian Holstein. Milk quota had not any influence on the economic weights for beef performance traits, on feed conversion in bulls and on daily gain on fattening bulls, but influenced economic weight of milk yield and cow longevity. There were only minor differences in economic values of functional traits. In all cases discounted economic weights were lower than economic weights calculated without discounting. The standardised economic weights of the most considered traits made 3–8% of the economic weight for milk yield. Only feed conversion of bulls amounted up to 48% and cow longevity 22% of the economic value of milk yield. It was discounting that had a relevant impact on the economic weight of cow longevity. Selection gain in the first lactation was influenced neither by quota nor by discounting, but discounted total profit per closed herd decreased by 59%.Defining the breeding objective, milk production, content of milk components, interval between the first and last successful breeding of heifers, cow longevity and feed conversion rate of bulls should be included as the traits with the most higher economic value. Those traits should be included also to the selection index.

Introduction

For establishing a total merit index after Hazel the relative economic weights of the traits considered in the aggregate genotype (breeding objective) have to be known. The optimal way of dealing with complex breeding objectives including several traits is index selection (Hazel, 1943). The derivation of a selection index involves decision of which traits are economically important, calculation of marginal gains for those traits, decision about of traits to be recorded, calculation of phenotypic and genetic parameters related to the complete set of traits, and derivation of index weights based on all this information. Although the method was developed more than 60 years ago, it is still considered superior to all other approaches of multiple trait selection (Sölkner and Fuerst, 2002).

The recognition of the importance of functional traits in cattle (health, fertility, metabolic stress, longevity), and possible role of animal breeding in avoiding deterioration and a possibility of improving functional traits has lead to research activities in many EU countries (Groen et al., 1998). The term "functional traits" describes a set of characteristics of animals whose effect on the economic efficiency of cows is through reduction of costs rather than increase of product output (Groen et al., 1996). It replaced the term "secondary traits". For a long time genetic evaluation of health, reproductive traits, herd life and others was limited due to low heritability of many of the traits and inaccuracy of data on individual cows. At the time research on functional traits has intensified and many breeding organisations are routinely computing and publishing breeding value estimates for those traits. Partly this process was stimulated by an EU-sponsored Concerted Action, with participating scientists from all EU countries, Czech Republic, Norway, Switzerland, Israel, Canada and INTERBULL (Sölkner and Fuerst, 2002). GIFT – the acronym stands for "genetic improvement on functional traits in cattle" – brought these people together to discuss issues of recording and genetic evaluation of functional traits and enhanced collaborative efforts and exchange of computer programs used for genetic analysis of functional traits.

With the widespread use of artificial insemination over the last decades, male fertility has not received much attention (Boelling et al., 2002). The decline in fertility of dairy cattle and unfavourable genetic correlation between fertility and milk yield (Royal et al., 2002), prompts the need to broaden breeding goals to include fertility. In Sweden a comprehensive breeding goal for dairy cattle includes female fertility and calving traits as well as production and health traits (Larsson and Andersson-Eklund, 2002). The fertility of cows and their calving performance are, however, equally important for the economy in the milk production. The calving traits are also important in an animal welfare perspective.

Breeding objective and recording of the traits. In index selection, the breeding objective is defined by a linear function of economically important traits. Three basic conditions have to be met to make sense of an inclusion of an additional trait in the selection index. First, the economic impact of the trait has to be sufficient, second, information about the trait of interest on candidates for selection or relatives thereof has to be available and third, there must be genetically determined variation of the trait in the population (Thaller, 1998). Recordability is not required as long as correlated traits which are more easily recorded are available (Sölkner and Fuerst, 2002).

Economic weights. Economic weights are necessary to determine the relative importance of the traits constituting the breeding objective**.** Economic weight of carrier, fat and protein production was for Estonian cattle population calculated first in 1997 (Pärna and Saveli, 1997; Pärna and Saveli, 1998) and of some functional traits in 2002 (Pärna and Saveli, 2002). Annual genetic response in milk carrier, fat and protein yield was estimated 57.4 kg, 1.98 and 1.67, respectively (Pärna and Meier, 2001). Since 1997 the milk performance has risen more than 1000 kg, but the fertility parameters and further functional traits have deteriorated. The population size has decreased 6%. Increasing input prices for agricultural enterprises were not balanced by output prices. Preparing the joining of Estonia to EU, we have to consider the impact of quota on economic weights. After Groen et al. (1996) under quota conditions and decreasing milk prices functional traits like reproduction traits, which increase efficiency not by higher output of products but by reduced costs of input might have a bigger impact on the profit of dairy farmers and should therefore be included in breeding programmes. Apart from economic reasons for including functional traits in the breeding programmes there are several non economical reasons, for example ethical reasons and consumer concern, which are becoming more and more important (Dempfle, 1992; Groen et al., 1996; Olesen et al., 1999). The including of functional traits in breeding programmes will have a major impact on the expected selection response of the functional traits and will result in only small losses of the expected selection response of the production traits (Fewson and Niebel, 1986).

In this study absolute and relative economic weights estimated with a herd model under assumed quota on the milk production with given fat and protein content and non quota conditions will be given for the Estonian Holstein population. The following traits were considered: milk yield, fat and protein content, daily gain in fattening bulls, dressing percentage in bulls, feed conversion in bulls, net daily gain in bulls, calving interval, age at first breeding, interval between the first and last breeding of heifers, cow longevity. The discounted economic weights of above named traits were calculated to investigate time delay influence.

Keywords: economic weights; functional traits; production traits.

Materials and methods

For the derivation of the economic weights, a bioeconomical model of a closed herd which included the whole integrated production system of dairy breed was used (Wolfová et al., 2001). The total discounted profit for herd was calculated as the difference between all revenues and costs that occurred during the whole life of animals born in the herd in one year and that was discounted to the birth year of these animals:

$$Z_T^0 = Z^0 S_{StFU}$$

$$Z^0 = \sum_{k \in \Omega} N_k (R_k q_{R_k} - C_k q_{C_k})$$

with Ω={*BCa*, *CCa*, *FBu*, *BHei*, *CHei*, *CCo*1, *CCo*2+}

where

Z_T^0 – total discounted profit in the population of the given breed (closed herd)

S_{StFU} – number of standard female units (StFU = one cow place occupied during an entire year)

Z^0 – discounted profit per StFU

N_k – average number of animals in category *k* per StFU

R_k,C_k – average revenues and costs, respectively, per animal of category *k*

q_{R_k}, q_{C_k} – discounted coefficient for revenues and costs, respectively, in category *k*

The discounting coefficients for the revenues were calculated by the following equation:

$$q_{R_k} = (1+u)^{-\Delta t_{R_k}}$$

where

Δt_{R_k} average time interval between the birth of animals of category *k* and the time of collecting revenues

u discounting rate (expressed as a fraction).

The discounting coefficients for the costs were calculated in the same way and with the same discounting rate. The categories (*k*) of animals were the following:

BC – breeding calves with rearing period from birth to 6 months of age (male and female calves together)
CCa – calves culled within 6 months of age (only calves not suitable for breeding)
FBu – fattening bulls, from 6 months of age to slaughter
BHei – breeding heifers (used for replacement of the cow herd) from the age of 6 months to 1st calving
CHei – heifers culled before calving (not suitable for breeding or not pregnant)
CCo1 – cows culled in the first lactation
CCo2+ – cows culled in the second and later lactations.

The not discounted profit (that means the average profit per year in the whole balanced system) was calculated by setting *u*=0 so that all *q*'s took the value 1.

The discounted economic weight of a given trait *i* was defined as the partial derivate of the total profit function for the closed herd with respect to the given trait whereby all traits were assumed to take their mean values:

$$a_i = \left\{ \partial Z_T^0 / \partial x_i \big|_{\mathbf{x}=\boldsymbol{\mu}} \right\} / S_{StFU}$$

where

x_i – value of the trait *i* under consideration

x – vector of the values of all traits (dimension of **x** = number of traits)

μ – vector of the means of all traits.

Detailed definitions of all evaluated traits and complete description of the method and the individual models used for the calculation of economic weights can be found in Wolfová and Wolf (1996). A computer program developed by Wolfová and Wolf (1996) was used for the calculations of economic values for the various traits. The situations with and without milk quota were investigated. It was assumed that the number of breeding heifers was constant when increasing the length of production life in cows.

The situation based on production and economic data of the joint stock companies (Estonia, Väätsa Agro, Tartu Agro and Adavere) was defined for the Estonian Holstein population as follows. The 305-day milk production of the first lactation was 5539 kg, 227 kg fat and 179 kg protein. Net daily gain in bulls is derived based on dressing percentage of bulls. The age structure of the herd assuming maximum 10 lactations per cow. The statistical data were taken from the Results of Animal Recording in Estonia 2000. The average number of inseminations for pregnancy for heifers was 1.5 and for cows 2.0. Interval between the first and last breeding in heifers was 26.8 days and interval between calving and the first breeding in cows 83.3 days. Non-return rate-90 for heifers – 65.9%, for cows – 49.6%. The average service period was 129 days, and calving interval was 410 days. Basic price of milk 3.0 EEK/kg, price for 1% protein content in milk 0.3 EEK, price for 1% fat in milk 0.1 EEK. 1 EUR=15.65 EEK.

Results and discussion

Economic weights. Absolute economic weights for all traits considered are given in table 1. Milk quota had not any influence on the economic weight on beef performance traits, on feed conversion in bulls and on daily gain on fattening bulls, but influenced the economic weights of milk yield and cow longevity. There were only minor differences in economic values of functional traits.

Table 1. Economic weights of Estonian Holstein
Tabel 1. *Eesti holsteini tõugu veiste majanduslikud kaalud*

Trait *Tunnus*	Unit *Ühik*	Economic weights (in EEK per unit of given trait and per standard female unit) *Majanduslikud kaalud (kroonides, tunnuse ühiku ja standardlehmaühiku kohta)*			
		without quota *ilma kvoodita*		with milk quota[A] *piimakvoodiga*[A]	
		u=0.10	u=0	u=0.10	u=0
Milk yield / *Piimatoodang*	kg	2.4	3.9	2.0	2.3
Fat content / *Rasvasisaldus*	%	–163.0	–267.4	–163.0	–267.4
Protein content / *Proteiinisisaldus*	%	844.1	1384.6	844.1	1384.6
Net daily gain in bulls / *Pullide netoiive*	g/day / *g päevas*	–3.6	–1.8	–3.6	–1.8
Dressing percentage / *Tapasaagis*	%	45.1	63.3	45.1	63.3
Feed conversion / *Söödaväärindus*	MJ NE/kg	–398.1	–565.1	–398.1	–565.1
Daily gain in fattening bulls *Nuumpullide massi-iive*	g/day *g päevas*	–1.8	–1.8	–1.8	–1.8
Interval between 1st and last successful breeding in heifers *Mullikate esimese ja tiinestava seemenduse vaheline intervall*	days *päeva*	–8.3	–6.8	–8.4 –	–7.1
Calving interval / *Poegimisvahemik*	days / *päeva*	–5.5	–1.7	6.1	–3.9
Cow longevity / *Lehmade kasutusiga*	lactations / *laktatsioon*	10.3	624.5	–75.6	302.5
Age at first breeding / *Esmaseemendusiga*	days / *päeva*	–3.8	–0.2	–3.9	–0.6

[A]With constant fat and protein content,
[A]*Konstantse rasva- ja proteiinisisaldusega*

In table 2 the relative economic weights per genetic standard deviation and the relative economic weights in relation to the most important trait, milk yield, are given. The results are presented for a discounting rate 0.10 and for the situation without discounting (zero discounting rate). Genetic standard deviations were taken from the literature (Miesenberger, 1998; Wolfová et al., 2001). In all cases discounted economic weights were lower than economic weights calculated without discounting. The differences in economic weights increased along with the time interval between birth of improved animals and impact of improved trait on revenues or costs. The difference in economic weights between discounted and not discounted economic values was especially high for cow longevity. Selection gain in the first lactation was influenced neither by quota nor by discounting, but discounted total profit per closed herd decreased 59%.

Table 2. Relative economic weights of Estonian Holstein (no quota)
Tabel 2. *Eesti holsteini tõugu veiste suhtelised majanduslikud kaalud (ilma piimakvoodita)*

Trait / *Tunnus*	Unit / *Ühik*	Genetic standard deviation[A] / *Geneetiline standardhälve*[A]	Economic weights / *Majanduslikud kaalud*: (in EEK) per standard deviation *(kroonides) standardhälbe kohta*		relative to milk yield *piimatoodangu suhtes*	
			u=0	u=0.10	u=0	u=0.10
Milk yield[B] / *Piimatoodang*[B]	kg	450	1755	1080	1.00	1.00
Fat content / *Rasvasisaldus*	%	0.207	–55.4	–33.7	–0.03	–0.03
Protein content / *Proteiinisisaldus*	%	0.095	131.5	80.2	0.07	0.07
Net daily gain in bulls *Pullide netoiive*	g/day, *g/päevas*	30	–54.0	–54.0	–0.03	–0.05
Dressing percentage / *Tapasaagis*	%	1.14	72.2	51.4	0.04	0.05
Feed conversion / *Söödaväärindus*	MJ NE/kg	1.5	–847.7	–597.2	–0.48	–0.55
Interval between 1st and last successful breeding in heifers, *Mullikate esimese ja tiinestava seemenduse vaheline intervall*	days *päeva*	10	–68.0	–83.0	–0.04	–0.08
Calving interval *Poegimisvahemik*	days, *päeva*	10	–17.0	–55.0	–0.01	–0.05
Cow longevity *Lehmade kasutusiga*	lactations *laktatsiooni*	180	368.6	6.1	0.22	0.01

[A]Literature values (Meisenberger, 1998; Wolfová et al., 2001)
[A]*Kirjanduse põhjal (Meisenberger, 1998; Wolfová et al., 2001)*
[B]With constant fat and protein content
[B]*Konstantse rasva- ja proteiinisisaldusega*

The standardised economic weights of the most considered traits made 3–8% of the economic weight for milk yield. Only feed conversion of bulls amounted up to 48% and cow longevity 22% of the economic value of milk yield. It was discounting that had a relevant impact on the economic weight of cow longevity. Selection gain in the first lactation was influenced neither by quota nor by discounting, but discounted total profit per closed herd decreased 59%.The economic value of production and functional traits are preliminary as many changes in Estonian dairy sector will be under consideration in the nearest future. Defining the breeding objective, milk production, content of milk components, interval between the first and last successful breeding of heifers, cow longevity and feed conversion rate of bulls should be included as the traits with the most higher economic value. Those traits should be included also to the selection index.

Economic situation. In 2000, relative stabilisation in the number of cows could be observed. The liquidation of cattle due to the unfavourable production conditions in 1999 has been stopped. Stronger and more competitive producers have survived. No considerable decline is expected in the number of cows within the next few years, even some increase is predicted. The purchase prices of milk increased by 44% in 2000 compared to the last year (Piirsalu, 2001). The main reason for the rise in price and the increase achieved in the Estonian export quota by almost two times is the result of the successful EU accession negotiations and the elimination of the 29% customs tariff within the quota and this should be emphasised. Nevertheless, despite the increase in the price of milk in 2000, most milk producers had no means for current repairs or investments, because the production costs of milk increased considerably due to the increase in the price of several major inputs (e.g. fuel, feedstuff, electricity). The rise of the USD compared to EURO has been of great influence.

There can be one single trend noted – the higher the milk yield per cow, the more effective the production in the terms of economy. In Estonia milk production is considered profitable when exceeding 4500 kg production per cow a year and this level has been reached already. The trends of the Estonian milk production policy in 2000 were evaluated by the state's direct aid to dairy cows. Subsidy per cow was 1,065 EEK. In 2000, for the first time, the total of 8.7 million EEK were allocated for the dairy sector and the breeding of dairy cattle out of the 16 million EEK allocated for the joint stock companies from the state subsidies. The system of milk quotas will be of great importance for Estonia in the nearest future.

As the production of beef is dependant on the number of milk cows, in 2000, the beef production decreased, having the greatest decline among the branches of meat production. The purchase prices have remained low during the recent years and it has resulted in the decreasing interest of the producers to fatten animals.

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