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THE POTENTIALS OF USING SELECTION INDEX IN THE ASSESSMENT OF BREEDING VALUES OF HOLSTEIN BREEDS IN SERBIA

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Abstract: The conducted research was aimed at constructing equations of selection index that would be used in the selection of the Holstein-Friesian breed animals in Serbia. The construction of the selection index includes the most important milk traits observed in standard lactation: milk yield (MY305), milk fat content (% MF305) and protein content (% MP305). The variance and covariance necessary for the construction of selection index are calculated using the mixed model by the method of least squares. The economic value of traits is expressed as a ratio of relative changes in costs per unit of traits included in the selection index. Livestock included in the research produced, in the first standard lactation, an average of 7681 kg of milk with 3.58% milk fat and 3.28% protein. The equation of the selection index presented in the paper is selected from the group of equations of selection index, as an equation with the highest correlation between the equation and the aggregate genotype, which amounted to 0.2156.

Key words: selection index, breeding value, milk traits, Holstein breed

Introduction

Breeding domestic animals is a very complex zootechnical procedure both in terms of objectives to be achieved and in the methods used. A large number of participants are involved in this business, ranging from breeders, basic, regional and national breeding organizations, centres for artificial insemination, professional and scientific organizations and universities, who define breeding objectives in accordance with the breeding program (*Stanojevic et al. 2015*).

In designing the breeding programs, selection objectives are defined which involve a larger number of traits that affect the economic efficiency of cattle production. One of the key issues when choosing parental pairs is the identification of genetic superior livestock that possess genes whose frequency we want to raise in the next generation. One of the most efficient ways for the assessment of breeding values for a larger number of traits is the use of the selection index (*Sölkner et al., 2000*). The selection index was used for the first time in the selection of plants, whereas *Hazel and Lush (1942)* were the first to use this method in the selection of domestic animals.

The selection index combines production levels of two or more traits. The result of the selection index is the score whose basis serves for ranking and selecting livestock. In assessing the breeding value, selection index takes into account the economic value of all traits included in the index and their manifestation, heredity and connection and combines it all into one single value (selection score) that we use for ranking livestock when selecting (*Hazel and Lush, 1942; Hazel 1943*). Another advantage is its relatively simple application when the equation of selection index is determined (*Radojkovic et al., 2010; Popovac et al., 2014*). Thus obtained score is in maximum correlation with the genetic contribution of the individual unit. When assessing the breeding value by using the selection index, one can use the data on production results of the very individual unit and its relatives.

In the past, the largest number of selection indices was designed in a way to include only productive traits such as milk yield, milk fat and proteins content (*Miglior et al., 2005*). Modern breeding programs have repositioned the focus from solely milk production traits to also include functional traits, longevity and traits of the type. Thus defined breeding programs are aimed at creating a healthier and economically efficient livestock units.

The aim of this work is to design equations of selection index with differently expressed economic values of traits and their use in assessing the breeding value of cows and bulls of the Holstein breed.

Materials and methods

In the design of selection indices it is necessary to know the values of genetic and phenotypic variances and covariances, as well as the economic value for each trait involved in the design of selection index equation. For calculating the genetic and phenotypic variance and covariance, the research used production results that were achieved by 5123 primiparous in standard lactation. These livestock produced on 7 farms of the Agricultural Corporation Belgrade from 2006 to 2012. All the livestock were under milk yield control. The livestock were offspring to 53 bull-fathers, of which each bull had at least 5 daughters, while the average number of daughters per bull was 96.7.

The breeding value rated by the selection index method can be represented by the following general equation:

$$I = b_1 (X_1 - \bar{X}_1) + b_2 (X_2 - \bar{X}_2) + ... + b_n (X_n - \bar{X}_n)$$

where:

I – relative breeding value of the livestock unit estimated by the selection index, i.e. the value of selection index determined for the given livestock,

b_i – multiple regression coefficients for each trait included in the selection index,

$(X_i - \bar{X}_i)$ – the difference between the phenotypic value of the trait included in the selection index for a given individual and the population average for a given trait

The construction of the selection index includes traits of primary importance regarding milk production, namely: milk yield (MY305), milk fat content (%MF305) and protein content (%MP305). All properties were observed in standard lactation.

The values of genetic and phenotypic variances and covariances were calculated using the least squares method (Harvey, 1990) and by using the following mixed model:

$$Y_{ijklm} = \mu + F_j + G_k + S_l + U_m + o_i + e_{ijklm},$$

Where:

Y_{ijklm} – phenotypic manifestation of surveyed traits,

μ-general population average,

F_j-fixed effect of the j farm,

G_k- fixed effect of the k year of calving,

S_l- fixed effect of the l calving season,

U_m- fixed effect of the m groups based on the age at first calving (I-age at first calving less than 24 months, II-age at first calving from 24 to 29 months, III-age at first calving from 29 to 35 months, IV- age at first calving from 35 to 41 months, V-age at first calving over 41 months),

o_i- random effect of the i sire,

e_{ijklm}- random error.

In the absence of stable market relations over a longer period of milk production in our country, which are essential for determining the economic value of traits in terms of use of bio-economic model, this paper uses a methodology which is based on the use of the relationship between costs and expression of traits (*Radojkovic 2000, Vukelic et al., 2004; Popovac et al. 2014*). The economic value expressed in this way represents a relative economic indicator.

In calculating the economic value of traits included in the construction of the equation of selection index, the starting point was that all the traits included in the selection index are registered in standard lactation, and that all livestock achieved 305 feeding days during standard lactation. The main economic assumption is that the costs of one feeding day as economic size are the same throughout the surveyed period, which is not the case in practice, but higher costs at the initial phase of lactation compensate to some extent lower costs at later stages.

The economic value is expressed as the difference in costs per trait unit that appeared as a consequence of the implementation of the breeding program. Milk yield in standard lactation (MY305) served as the primary trait in the research. The breeding objective here was set as milk yield of 9000 kg of milk with 3.70% milk fat and 3.40 protein. The economic value of traits included in the construction of the selection index is obtained by comparing the relative indicators of cost reduction between the primary trait and other two traits which appears after the implementation of the breeding program. The economic values of observed traits are given in Table 1 and Table 1a:

Table 1. Relative economic value of traits (REV_1)

Trait	MY305 (kg)	%MF305 (%)	%MP305 (%)
Economic value of traits	1	980	1170

The economic value of traits included in the construction of the selection index is also calculated according to the method used by *Sharma and Basu (1986), Falconer and Mackay (1997)* and *Cameron (1997)*, where the relative economic value is expressed as $1/\sigma_p$, where σ_p is the phenotypic standard deviation of the observed trait.

Table 1a. Relative economic value of traits (REV_2)

Trait	σ_p	$1/\sigma_p$	REV_2
MY305 (kg)	1322	0,0007564	1
%MF305 (kg)	0,18	5,5556	7344,8
%MP305 (kg)	0,11	9,0909	12018,6

Results and Discussion

Table 2 shows the average values and variability of milk traits in standard lactation achieved by the livestock included in the research:

Table 2. Average values and variability of milk traits in standard lactation

Trait	n	$\bar{x}$	SD	Cv (%)
MY305 (kg)	5123	7681	1322	17,21
%MF305 (%)		3,58	0,18	5,10
%MP305 (%)		3,28	0,11	3,26

Livestock included in the research had, in standard lactation, an average production of 7681 kg of milk with 3.58% milk fat and 3.28% protein. The determined values are significantly higher than the values identified on the same population in the research by *Đedović (2000)* and *Beskorovajni (2000)*, while the given results are in accordance with the results determined by *Carlen et al. (2004)* and *Stanojević et al. (2012).*

Table 3 shows the results of examining the impact of factors on the traits included in the research.

Table 3. The values of F-tests for examined factors

Trait	F-value			
	Farm	Year	Season	Age at 1st calving
MY305	$0{,}581^{nz}$	$11{,}92^{**}$	$11{,}40^{**}$	$5{,}05^{**}$
%MF305	$0{,}82^{nz}$	$7{,}38^{**}$	$6{,}47^{**}$	$1{,}13^{nz}$
%MP305	$0{,}83^{nz}$	$9{,}40^{**}$	$4{,}88^{*}$	$14{,}98^{**}$

The farm as a factor showed no statistically significant effect on observed milk traits, while other factors showed statistically significant effects on observed traits, except in the case of age which had no statistically significant effect on milk fat content.

Table 4 shows the values of variance and heritability coefficients for observed traits.

Table 4. The values of variance and heritability coefficients of milk production traits

Traits	σ_a^2	σ_a^2	h^2	S_h^2
MY305	75299,61	1825445,1	0,165	0,036
%MF305	0,00087	0,03412	0,102	0,026
%MP305	0,00019	0,01169	0,065	0,020

The values of heritability coefficients had their values from 0,065 in terms of protein content in milk to 0,165 in terms of milk yield. The determined values of heritability coefficients are significantly lower compared to the results gained by *Carlen et al. (2004)* and *Pham Manh Hung et al. (2008).* Similar values were achieved in the research by *Stanojevic et al. (2012)* and *Đedović et al. (2013).*The determined values of heritability coefficients of milk production traits suggest the possibility of their improvement through selection, even though mainly external environmental factors influence their expression.

Table 5 shows the values of coefficients of phenotypic (above the diagonal) and genetic (below the diagonal) correlations.

Table 5. The values of coefficients of genetic and phenotypic correlations of milk production traits

Trait	MY305	%MF305	%MP305
MY305	-	-0,095	-0,209
%MF305	-0,1	-	0,002
%MP305	0,074	-0,265	-

The determined values of genetic correlations had their value from -0.265, in terms of milk fat content and protein content in standard lactation, to 0.074 in terms of genetic correlation between milk yield and protein content in standard lactation. The determined values of genetic correlations between milk production traits are close to the values obtained in the research by *Pantelić (2011)* and *Pham Manh Hung et al. (2008)*. The values of the phenotypic correlation are small close values to the values of genetic correlations and are consistent with the values obtained by *Nistor et al. (2009).*

After solving the system of normal equations and determining the coefficients of multiple regression, the equation of selection index was constructed with the following form:

Table 6. The equation of selection index and the value of the coefficient of correlation index with aggregate genotype (r_{IAG})

REV	Selection indices equations	r_{IAG}
REV_1	$I=0,046^1(X_1-7681)+28,395^2(X_2-3,58)+157,44^3(X_3-3,28)$	0,2156
REV_2	$I=0,048^1(X_1-7681)+161,635^2(X_2-3,58)+281,772(X_3-3,28)$	0,1942

[1]- the coefficient of multiple regression of coefficients for MY305, [2]- multiple regression coefficient for %MF305, [3]-multiple regression coefficient for %MP305, $X_{1,2,3}$- phenotypic value of the livestock for traits included in the SI

Presented equations of selection indices are selected from the group of equations of selection index as equations with the highest coefficient of correlation between the equation and aggregate genotype, which amounted to 0.2156 or 0.1942 for second equation of SI. Constructed equations combine, in an optimal way, phenotypic expression levels of the three traits that are included in it, where the resulting score is in maximum correlation with the breeding value of the livestock.

Conclusion

The research determined an average milk yield in the first standard lactation of 7681 kg of milk with 3.58% milk fat and 3.28% protein. The research identified a high variability of milk production traits, which is, on one hand, conditioned by hereditary factors and, on the other hand, environmental factors. The observed milk production traits were highly statistically influenced by the year of calving and calving season, as well as the age at first calving. The heritability coefficients calculated in the research indicate that the observed milk production traits in the studied population are hereditary low.

Constructed equations of the selection index should serve as a simple and fast way to rank cows in their selection as parents of the next generation. Also, the constructed equations of selection index only include milk production traits. A selection conducted in this way would be one-sided and, in the future, there should be more work on the inclusion of a certain number of traits such as reproductive traits and fitness traits in the construction of selection index. Special attention should also be given to the introduction of more complex and precise methods for assessment of breeding values such as BLUP and BLUP AM method.

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Mogućnosti upotrebe selekcijskog indeksa u proceni priplodne vrednosti krava holštajn rase u Srbiji

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Rezime

Sprovedeno istraživanje imalo je za cilj konstruisanje jednačine selekcijskog indeksa koja bi se koristila u odabiru grla holštajn-frizijske rase u Srbiji. U konstrukciju selekcijskog indeksa uključene su najvažnije osobine mlečnosti posmatrane u standardnoj laktaciji: prinos mleka (PM305), sadržaj mlečne masti (%MM305) i sadržaj proteina (%MP305).

Varijanse i kovarijanse neophodne za konstrukciju selekcijskog indeksa izračunate su primenom mešovitog modela metodom najmanjih kvadrata. Ekonomska vrednost osobina je izražena kao odnos relativne promene troškova po jedinici osobina uključenih u selekcijski indeks.

Grla obuhvaćena istraživanjem prosečno su proizvela u prvoj standardnoj laktaciji 7681 kg mleka sa 3,58 % mlečne masti i 3,28% proteina. Jednačina selekcijskog indeksa prikazana u radu odabrana je iz grupe jednačina selekcijskog indeksa, kao jednačina sa najvećom korelacijom između jednačine i agregatnog genotipa, koja je iznosila 0,2156.

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