GENETIC IMPROVEMENT OF FERTILITY IN SHEEP BY SELECTION ACCORDING TO PHYSIOLOGICAL PARAMETERS**

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Abstract: In this paper, fertility parameters of sheep are discussed and principles analyzed in order to obtain the optimal methods for their evaluation. Mathematical procedures for evaluation of genetic and phenotypic parameters and anticipation of genetic values, today, are mainly based on different linear and non-linear concepts, therefore it is necessary to accept the reality that there is no absolute accuracy. Special emphasis is on the possibility of use of physiological quantitative fertility indicators in sheep selection, considering that there is correlation between them and fertility traits. In this regard, the degree of response to direct and indirect selection within population is analyzed in order to established the nature of parameters necessary for evaluation of data and determine the relative degree of such response.

Key words: sheep, fertility, selection, physiological parameters

Introduction

In modern sheep production, most of the income is realized by production and selling of lambs. Therefore, the emphasis in sheep production is on early maturation and reproductive efficiency of individual animals. At the same time, genetic potential of reared populations has to satisfy high criteria (*Petrović*, 2007).

It is considered that improvement of sheep in future has to provide early maturation in sheep, so that the first fertilization occurs at the age of 6 to 7 months. Also, seasonal character of the oestrus incidence and lactation has to be eliminated and fertility has to exceed two lambs per sheep and partus.

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In order to achieve these high objectives, permanent genetic improvement of traits which are of interest to breeders is necessary (*Lewis et al.,* 1996*, Okut et al.,* 1999*, Sakul et al.,* 1999*, Bromley et al.,* 2000*, Petrović et al.,* 2003*,* 2004, 2005, 2006).

Development of theoretical procedures and discovering of optimal methods for evaluation of genetic fertility parameters is of special interest (*Rao et al.,* 2000*, Notter et al.,* 2000, 2001, 2002*, Banos et al.,* 2002*, Duguma et al.,* 2002*, Hanford et al.,* 2002). Especially since hormones responsible for sheep fertility are under strict genetic control (*Zarazaga,* 1998*, Notter and Chemineau* 2001).

Objective of this review is to indicate the nature of fertility factors in sheep and possibilities for use of physiological quantitative parameters in selection.

Analysis of sheep fertility factors

Number of offspring obtained per lambing is one of the most important parameters of sheep productivity, and according to some authors (*Sakul et al.,* 1999*, Petrović,* 2000) it is more important than gain, i.e. mass of lambs. This means that biological efficiency of sheep in regard to meat, milk and wool production is conditioned by fertility, i.e. reproductive potential (*Greet et al.,* 1995*, Notter et al.,* 2000).

At he beginning of development of genetics, farmers, relying on the heredity, supported the thesis that increase of fertility by methods of genetics was moderate and insufficiently efficient (*Petrović et al.,*1993). In spite of such conception, later communications and latest researches on results of selection in sheep on fertility (*Rao et al.,* 2000) have changed this view considerably.

All of the facts mentioned above, as well as presence of less known fertile sheep breeds such as Finnish and Romanov sheep, create assumptions that by methods of programmed breeding work, genetic potential of sheep fertility can lead to higher level, in range from one to three lambs per head and partus.

Success in selection of sheep in regard to their fertility greatly depends on genetic variability of reproductive components (*Petrović,* 1992*, Petrović et al.,* 1997, 2001, 2002).

Heritability for onset of puberty is low and within the interval of 0,1 to 0,26 (*Petrović,* 2000).

Expression of oestrus and duration of breeding season in sheep is also of great importance for total sheep production, since certain sheep breeds have

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so called extended sexual season: Romanov sheep Finnish sheep, D'man, which is almost aseasonal.

Beside differences in sexual season in certain sheep populations, the presence of difference in heritability with values from 0,17 to 0,25 was observed (*Petrović,* 2000).

Range or norm of ovulation in sheep is still great challenge for the science, regardless of the fact that it is generally known that it is under control of larger number of genes, i.e. its poligeneous character. Activities directed to gene identification responsible for this trait are in progress (*Galloway et al.,* 2000*, Davis et al.,* 2001*, Grant et al.,* 2001*, Wilson et al.,* 2001). The presence of high variability of ovulation rate between certain breeds was established. So, average ovulation rate in Merino breed is 1,2 and in Cambridge population even 5,3 (*Bindon et al.,* 1996).

Heritability values for ovulation rate are different and vary from 0,05 in Merino breeds in Australia to 0,50 in Finnish breed in Ireland, and heritability for this trait is 0,21 and repeatability 0,37 with high coefficient of variation (30%) (*Petrović,* 2000).

For traits of sheep fertility, of great importance is also embryonic mortality, which is especially present during first four weeks of pregnancy, when 20 - 30% of fertilized egg cells can be lost, and which is in negative correlation with ovulation rate (*Perez et al.,* 1994).

Embryonic mortality is trait of low heredity, considering that heritability has value of 0,07. This means that genetic factors play small role compared to total variability of all effects in population.

Evaluation of genetic fertility parameters

Evaluation of genetic parameters which are of importance for increase of fertility in sheep is subject of constant discussions and scientific analysis (*Van Wyk et al.,* 2002*, Petrović,* 2006). The same question is asked over and over: which method of evaluation of genetic fertility parameters is optimal for given population in certain rearing conditions?

Mathematical procedures for evaluation of genetic and phenotypic parameters and prediction/anticipation of genetic values are based on different concepts. For instance, beside linear also non-linear procedures for evaluation of genetic parameters are used (*Matos et al.,* 1997*, Gabrilidis et al.,* 2000*, Petrović,* 2000) which tells us that there is still no completely reliable method for evaluation.

Fertility traits are conditioned by many limiting factors and occur only in sexually mature animals. Generation interval is long and heritability low.

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This, however, imposes the need for discovering suitable traits which can be used for evaluation or anticipation of individual's genotype before sexual maturity (*Petrović et al.,* 2005).

Considering mentioned factors, our attention should be directed to physiological sheep traits, first of all hormone, metabolite or ferment levels.

Selection according to physiological parameters

Use of physiological quantitative parameters in sheep improvement in order to realize increased fertility is reasonable only within the population and if adequate data exist. Accordingly, we shall analyze the principles of the degree of response on direct and indirect selection within population in order to establish what kind of parameters are necessary for evaluation of data and determine relative degrees of such responses.

If trait l is marked as fertility which has to be improved, and trait 2 as physiological component, than trait 1 has following parameters:

$h1^2$ - Heritability
$\delta P1^2$ - Phenotypic variance
P1 - Phenotypic value
$\delta A1^2 = h1^2 \delta P1^2$ - Additive genetic variance
A1 – Breeding value

Trait 2 would have the same parameters, as for instance $h2^2$, P2 etc. Also, in both traits the following is included:

rA – Genetic correlation (or rA12)
$COVA = rA\delta A1\delta A2$ – Genetic covariance
rP – Phenotypic correlation
$COVP = rP\delta P1\delta P2$ – Phenotypic covariance
SI – Selection index
rASI – Correlation between selection index and breeding value
i – Selection intensity

Use of standard and equivalent formulas/equations it is possible to describe selection response.

As a result of direct or immediate selection in regard to the own productivity of sheep P1, the response of fertility trait (R) would be:

$$R_1 = i\ h_1^2 \delta P_1 = i\ h_1 \delta A_1 = \delta^2 A_1 / \delta P_1 \qquad (1)$$

Reaction of the connection of fertility traits, as consequence of selection, in physiological quantitative changes P_2, will be like this:

$$R_1 = irAh_1h_2\delta P_1 = irAh_2\delta A_1 = iCOV_A/\delta P_2 \qquad (2)$$

Reaction of the connection of fertility traits, as a result of selection, according to index of any trait or their combinations has the following form:

$$R_1 = irA\delta A_1 = iCOV(A_1,SI)/\delta_1 \qquad (3)$$

It is obvious that equations 1 and 2 represent specific cases of equation 3, for direct selection $SI = P1$, with accuracy of the index $rASI = h_1$, and for indirect selection $SI = P2$, i.e. $rASI = rA\ h_2$.

The next important case is, when selection is carried out based on average of the productivity of female breeding animals, selection of rams according to average level of fertility of n-daughter:

$$rASI = \frac{1}{2} h1 \left(\frac{n}{1+(n-1)t1} \right)^{\frac{1}{2}}, \text{ where}$$

t1 – Intraclass correlation of half siblings.

When there is no correlation of the mean for brothers, than $t1 = 1/4\ h1^2$ and $rASI \rightarrow 1$, and in case of increase of the size of progeny group, $rASI \rightarrow \frac{1}{2} h1/\sqrt{t1}$.

If selection of rams is performed based on productivity of half sisters, coefficient ½ in equation 4 is changed into ¼. Relative efficiency of direct and indirect selection, in equal intensity, for specific animals would be:

$$\frac{R_1\ indirektna}{R_1\ direktna} = \frac{rA\,h_2}{h_1} = \frac{COVA\delta P_1}{\delta^2 A_1\ \delta P_2}$$

Efficiency of selection of rams based on physiological parameters, when own data are considered, level of observed traits in half brothers or daughters, with application of previous equations (2, 3 and 4), is proportional:

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$$\left(r A \mathrm{h}_2 \ / \ \mathrm{h}_1 \right)\left(\frac{n}{1+(n-1)\,\mathrm{t}_1}\right)^{-1/2}$$

In previous considerations the possibility of return use of data wasn't considered. In case of genetic correlation between each subsequent observations, when same genes are expressed and each observation has the same variance and covariance with other traits in the equation, patterns/forms can be modified in the following way:

$$\delta^2 P_1 \text{ as } (C_1 + (1 - C_1) / n)\, \delta^2 P_1,$$

$$\mathrm{h}^2_1 \text{ as } \mathrm{h}^2_1/(C_1 + (1 - C_1)/n, \text{ where:}$$

C_1 – Repeatability (intraclass correlation) between each of n repeated observation of the trait 1. For trait 2 analogue form/equation is derived, but δA_1^2 in case of both traits 1 in COVA, i.e. rA for trait 2 are not changed. It is also necessary to consider, beside what is mentioned, changes occurring in generation interval.

If from observation to observation genetic expression of trait is altered, for instance, size of litter per lambing or hormone level in cycle stages, than components are entered into index separately.

By bringing together information regarding size of litter and physiological parameters, the selection index can be constructed. So, in index for selection of female breeding animals, using own fertility results (trait 1 in index) and physiological parameters (trait 2), the valuations are needed: δP_1^2, $\delta^2 P_2^2$ and COVP for phenotypic covariance of matrix, as well as evaluation δA_1^2 COVA for genetic covariances of matrix. Relations of index coefficients are marked with b1 for trait 1 and b2 for trait 2, which can be seen from the following formula:

$$\frac{b_2}{b_1} = \frac{\delta^2 P_1 \, \mathrm{CovA} - \mathrm{CovP}\,\delta^2 A_1}{\delta^2 P_2 \, \delta^2 A_1 - \mathrm{CovPCovA}} = \frac{(r A \mathrm{h}_2 \ / \ \mathrm{h}_1 - rP)\delta P_1}{1 - rPr A \mathrm{h}_2 \ / \ \mathrm{h}_1)\delta P_2} \quad (6)$$

We can see that stated equation, beside genetic factors, includes also phenotypic variance, covariance and correlation, which all together influences the accuracy of the index. Depending on the situation, i.e. if in

selection of rams parameters of half brothers, daughters or own physiological parameters are used, it is necessary to know $\delta P_1{}^2$, $h_1{}^2$ or $\delta A_1{}^2$, CovA or rAh_2, but not rA h^2 or $\delta A_2{}^2$.

If in construction of index two or more physiological characteristics were used, their genetic and phenotypic covariances are necessary (for instance CovA23).

Conclusion

Evaluation of genetic parameters which are significant for increase of fertility in sheep is subject of constant discussions and scientific analysis. The same question is asked over and over: which method of evaluation of genetic fertility parameters is optimal for given population in certain rearing conditions?

Regardless of the fact that accuracy of the evaluation of genetic fertility parameters is important factor in increase of number of lambs per female breeding animal, it is necessary to accept the reality that total accuracy doesn't exist.

Ideally, there would be an opportunity to determine which accuracy of the parameter evaluation is necessary, like for example in case of genetic covariance between traits.

This of course is not easy to determine, since all scientists engaged in genetics, statistics or physiology wouldn't be satisfied, therefore we must concur with saying that „accuracy is sufficient", keeping in mind procedures which we use today.

Use of physiological quantitative parameters in sheep improvement in increase of fertility is one of the procedures which can lead to success in sheep selection on fertility.

GENETSKO POBOLJŠANJE PLODNOSTI OVACA SELEKCIJOM PO FIZIOLOŠKIM KVANTITATIVNIM PARAMETRIMA

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Rezime

U radu se razmatraju parametri plodnosti ovaca i analiziraju principi iznalaženja optimalnih metoda za njihovu procenu. Ističe se da su matematički postupci za procenu genetskih i fenotipskih parametara i predviđanje genetskih vrednosti danas uglavnom zasnovani na različitim linearnim i ne linearnim konceptima, pa je zbog toga potrebno prihvatiti realnost da potpuna tačnost za sada ne postoji. Poseban akcenat se stavlja na mogućnost korišćenja fizioloških kvantitativnih pokazatelja u selekciji ovaca na plodnost, s obzirom da postoji korelacija između između njih i osobina plodnosti. U tom smislu, analizira se stepen odgovora na direktnu i indirektnu selekciju unutar populacije, kako bi se ustanovila priroda parametara neophodnih za ocenu podataka i utvrdili relativni stepeni takvog odgovora

Ključne reči: ovca, plodnost, selekcija, fiziološki parametric

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