Estimation of the genetic parameters for reproduction traits using a threshold model in Teleorman Black Head sheep breed

Rodica Ștefania Pelmuş* , H. Grosu, C. M. Rotar, Elena Ghiţă, Cristina Lazăr, Florin Popa

**Corresponding author e-mail:* pelmus_rodica_stefania@yahoo.com

[1] *Institutul National de Cercetare Dezvoltare pentru Biologie si Nutritie Animala Balotesti IBNA Balotesti, Calea Bucuresti no. 1, Balotesti, Ilfov*

SUMMARY

Text The objective of this study was to evaluate efficacy of threshold model use in breeding and heritability values estimation for reproductive trait in the Teleorman Black Head sheep breed. The pedigree consisted of 491 animals: 144 ewes, 17 rams and 330 lambs from the experimental farm of the National Research - Development Institute for Animal Biology and Nutrition Balotesti. The breeding value of the best Teleorman Black sheep for the number of born lambs ranged from 0.013 to 0.022. The heritability for the number of born lambs was low (0.01). The threshold model was adequate due to better accounting for total variability.

Keywords: threshold model, sheep, breeding value, heritability

INTRODUCTION

Reproductive traits are the most important factors affecting the profitability of sheep farming (Matos et al., 1997). In sheep production, fertility, litter size and lamb survival are the most important reproductive traits in all systems of sheep production and in all environments (Matika et al, 2002). The number of lambs at lambing is one of the reproductive components with special importance. Ekiz et al. (2005) pointed out that the major source of income and profitability in any sheep system is lamb production. Low heritability of reproductive traits is probably due to the greater proportional influence of environmental effects as well as little genetic variability for fertility, litter size, lamb survival and lambing frequency and other reproductive traits (Rosati et al., 2002).

Teleorman Black Head sheep is a breed with a longer breeding period compared to other breeds of sheep from Romania. This allows an easier synchronization of lamb and milk production with maximum market demand (Grosu et al., 2005). It is a breed with early sexual maturity. Young females and males are mating in their first year of life, respectively at the age of 7-10 months. This early first mating compared to 18 months, the date of the first mating in the other breeds of sheep raised in Romania, gives to this breed an indisputable economic advantage. Birth rate can rise frequently between 130-150%. It is the result of 95% fecundity and a prolificacy of about 130-160%. Breeding aspects of a breed influence milk and meat production (Grosu et al, 2005).

Some breeds close related with Teleorman Black Head breed are also raised in Serbia and Montenegro, Croatia, Hungary and Bulgaria where some differences have been observed. For example, in Serbia the name of the breed is Pvinicki, located at the border with Croatia and their ewes have the head of black colour (Grosu et al, 2005). In Croatia the breed is raised in Slavonia and Barnja from meat production. Morphological type of this breed is similar to that of the Teleorman Black Head breed. The fertility of the breed from Croatia is 120-130%. In Hungary the breed has a large milk production and a prolificacy of 160%. In Bulgaria the breed is called Blackhead Pleven Breed being considered the best breed sheep for milk production. The average milk production is 160-178 liters, the duration of the lactation is 180-200 days (Grosu et al, 2005). The average prolificacy is 130-160% in Blackhead Pleven Breed.

Threshold model used in reproduction for determination of genetics parameters with categorical traits were proposed by Gianola (1982), Gianola and Foulley (1983) and Harvill and Mee (1984) as the most theoretically acceptable method of analysis for categorical data. Meijering and Gianola (1985) showed that for some situations a linear model may perform just as well in terms of correctly ranking dairy sires. The threshold models assume a continuous normally distributed underlying liability scale for the trait. The threshold defines the categories that are observed. The solution to a threshold model is non-linear in computational complexity, and there must be back and forth calculations of thresholds and effects in the model until convergence of the system of equations stabilizes. There are various quantities which need to be computed repeated by in a threshold model analysis and there are based on normal distribution functions (Grosu et al., 2013).

The aim of this study was to evaluate efficacy of threshold model use in breeding and heritability values estimation for reproductive trait in the Teleorman Black Head sheep breed.

MATERIAL AND METHODS

The pedigree covered 491 animals - 144 ewes, 17 rams and 330 lambs from experimental farm of the National Research-Development Institute for Animal Biology and Nutrition in the period 2006-2011. The number of ewes in this period was different in each year; for example in 2006 was 40 ewes which had lambed, in 2007 was 64 which had lambed, in total pedigree were 144 different ewes. The number of lambs born was also different in each year, for example in 2007 were been born 85 lambs. The animals are maintained during the winter period in stabbing and during the warm season the ewes are maintained on natural pastures and cultivated grasslands. The mating season is autumn in September-October. The lambing were realised in January-March.

Analysis of the records was performed using the restricted maximum likelihood (REML) method procedure in R software realised by Horia Grosu. Linear model is a threshold model (Grosu et al., 2013) described as follows. The fixed effects are year of lambing and sex of lambs.

$$\lambda_{ijkl} = f(t)_I + S_j + H_k + a_l + e_{ijkl}$$

λ_{ijkl} = is unknown, underlying liability value for animal l, of sex j in herd k

$f(t)_I$ = is a function of the thresholds and probabilities of the lambing score of the animal belonging to category i

S_j = is a sex of lamb effect

H_K = is a year of lambing of lamb

a_l = is lamb additive genetic effect

e_{ijkl} = is a residual error effect

Let the model be written in matrix notation as:

$\lambda = Ft + Xb + Zu + e$

λ = is the vector of unobserved liabilities of each animal,

t = is the vector of m-1 thresholds,

b = is the vector of fixed effects in the model

u = is the vector of random effects, including random animal additive genetic effects

e = is the vector of random residuals, assumed to have mean 0 and variance of 1,

F = is a matrix of probabilities of an animal being in the various categories resulting in a function of the unknown thresholds

X, Z = are the usual design matrices of a linear model

The process begins by choosing the starting values for b, u and t. Let b = 0 and u = 0, then starting values for t can be obtained from the data by knowing the fraction of animals in the first category (i.e. = 0.5848=193/330 (193 lambs from category one – 1 lamb/lambing) and in the first two categories (i.e. =0.9818=324 /330 (193 lambs from category one and 131 lambs from category two – 2 lambs/lambing). From category three (3 lambs/lambing) there were 6 lambs. The threshold values that give those percentage are t_1= 0.177 and t_2 = 2.129.

The convergence for the results was attained after 10 iterations.

RESULTS AND DISCUSSION

The threshold model for estimate the breeding value of ewes includes the fixed effects and random effects for the trait *number of lambs born*. The trait, number of lambs born is determined on the hand by the effects of the genes that make up the polygenic complex of animal and on the other hand of the environment. In threshold model used for estimate the breeding value of sheep from Teleorman Black Head population were two fixed effects: year of lambing of lamb and sex of lamb. The random effects included in threshold model were additive genetic effects of sheep.

In our study the year of lambing had a significant effect on *born lambs number* ($p<0.05$). Influence of lambing year was given by the climate conditions and dependence of sheep to pastures, management and breeding conditions of mother. Significant effects of year on reproductive traits have been reported by several authors in different breeds (Vatankhah et al., 2008, Mohammadi et al., 2012, Nabavi et al. 2015).

In our study the fixed effect the sex of lamb had not a significant effect on *the number of lambs born* trait. Also, various authors had reported that the sex of lamb hasn't significant effect on number of lambs born (Vatankhah et al. 2008, Eteqadi et al., 2017).

Reproductive traits have very low heritability, implicitly strongly influenced by the particular environment and non-additive interaction. Prolificacy is dependent on several factors (breed, population and individual) and the environment (diet, hormone treatments, sheep age, sheep weight, mating season). The breed has a major influence, as there are breeds specializing in prolificacy such as: Bluefaced Leicester 180-200%, Friesian sheep breed 200-225%, British Dairy Sheep 220-300%, Romanov 250-300%, Finish Landrace 300%, Boorolla 250-300%. Specialized breeds in other countries achieve twice as much prolificacy compared to indigenous sheep breeds. Within each breed there are populations and within them individuals with much greater prolificacy. Selection is based on individual variability in order to achieve populations with high prolificacy.

In the Teleorman Black Head sheep population, the average for number of lambs born was 1.43±0.029. In this population 58.48% of ewes had simple lambings, 39.69% twin lambings and 1.8% had triplets. In another population from Teleorman Black Head breed sheep the average of lambs born was 1.28 in which 71.8% of ewes had simple lambing and 28.2% twin lambings (Grosu et al, 2005).

In our country the average prolificacy for Tsigai sheep breed is 105-108% and for Turcana sheep breed is 102-105% (Tafta, 1983). Various values of average prolificacy have been reported by other authors in different breeds. Similar results were obtained by Eteqadi et al. (2017) in Guillan sheep with a mean of 1.05 lambs born at birth and Analla et al. (1997) which reported a mean of 1.33±0.01 in Segurena sheep.

Selection for increasing prolificacy in sheep, although leading to a better average number of lambs born in selected lines, also leads to an increase in prolificacy variability. Even though the objective of the breeder is to maximise the frequency of an intermediate number of lambs born rather than the frequency of high number of lambs born. For instance, in the Lacaune sheep breed raised in semi-intensive conditions in France, ewes lambing twins represent the economic optimum. SanCristobal-Gaudy et al. (2001) reported in the Lacaune sheep breed the percentages of litters of 41.1, 47.5, 9.8, 1.5 and 0.1 respectively and 1, 2, 3, 4 and 5 or more lambs. The overall prolificacy of these ewes at their first lambing was 1.72. There was a tendency for the productivity of ewes to improve with age, generally reaching a maximum between three and six years of age.

In Table 1 are given the breeding values for the best 10 sheep in term of the number of lambs born. The breeding values for the number of born lambs were low for Teleorman Black Head sheep breed. Casellas et al. (2007) reported low breeding values in Ripollesa sheep breed and Hanford et al. (2006) obtained low breeding value in Polypay sheep.

In our study, the estimated heritability for number of lambs born in Teleorman Black Head population is 0.01. This heritability is lower (0.01) than the direct heritability 0.079 obtained by Nabavi et al. (2015). Various values of heritability have been reported by other authors in different breeds. Heritability estimate for number of lambs born was reported as 0.11 for Makooi sheep (Mohammadi et al. 2012), 0.053 and 0.059 for Turkish Merino and Dormer sheep (Ekiz et al. 2005; Van Wyk et al., 2003) respectively. Analla M. et al. (1997) obtained heritability estimates for number of lambs born approximately 0.08 for Segurena sheep.

Estimates of heritability for number of lambs born in our study are within the ranges cited in the scientific literature, which are generally low, less than 0.15 (Clarke et al., 1983; Gabina, 1989; Waldron and Thomas, 1983; Jorgensen, 1984). Number of lambs born is directly related to the ovulation rate, which is influenced by only a few hormones and the responsible genes, but selection only for number of lambs born would not be effective for increasing lamb production, since it does not include the survival rate and weight of the individual lamb at weaning (Rosati et al., 2002).

Table 1. Breeding value of the best Teleorman Black Head sheep for number of lambs born

Sheep no.	Estimate breeding value for number of lambs born
1	0.0220
2	0.0216
3	0.0216
4	0.0178
5	0.0162
6	0.0160
7	0.0157
8	0.0156
9	0.0134
10	0.0132

The heritability for number of lambs born was 0.01 in Teleorman Black Head sheep population. Heritability for the number of lambs born is in general agreement with those reported by Rao and Notter (2000), Safari et al. (2005), Hanford et al., (2006), and Vatanhah et al. (2008), though lower (0.10, 0.05, 0.06, 0.01, 0.11). Also, low heritability have been reported by Rosati et al. (2002), Maxa et al. (2007), Mohtari et al. (2010), and Rashidi et al. (2011).

The heritability estimates in number of lambs born in Rambouillet and Finnsheep breeds were 0.25 and 0.13 (Matos et al., 1997) higher than results of our study. With threshold analysis Matos et al (1997) obtained the heritability estimate for number of lambs born in Finnsheep breed ranged from 0.26 to 0.76 and reported that threshold models can explain a higher component of the genetic variation than linear models for classified traits.

Also, the high estimate of heritability for number of lambs born 0.34 was obtained by SanCristobal et al. (2001). Mekkawy et al., 2010 reported the heritability estimates for number of lambs born in Mule sheep 0.08 and 0.12-0.18 estimated by linear and threshold analysis of the real and simulated data.

Conclusions

The heritability of the number of lambs born was low showing a strong impact of environmental conditions over trait. The threshold model was adequate due to better accounting for the total variability. Applying the threshold model to categorical traits would increase the accuracy and consequently speed up the response to selection. The results confirm low influence of genetic assumptions of the number of lambs born.

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