Scientific Papers. Series D. Animal Science. Vol. LXIX, No. 1, 2026
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

GENETIC PARAMETERS FOR LITTER SIZE IN PROLIFIC BREED PALAS SHEEP

Rodica Ștefania PELMUȘ, Mircea Cătălin ROTAR, Mihail Alexandru GRAS, Cristina VAN

National Research-Development Institute for Animal Biology and Nutrition,
1 Calea Bucuresti, 077015, Balotesti, Romania

Corresponding author email: pelmus_rodica_stefania@yahoo.com

Abstract

The aim of present study was to estimate the genetic parameters for litter size in Prolific Breed Palas sheep with individual animal model. The data consists in records of 170 ewes at first parity, 142 ewes at second parity and 63 ewes at third parity. The pedigree consisted in 345 sheep: 131 ewes, 44 rams and 170 ewes with performances at first parity. The data were from Research and Development Institute for Sheep and Goat Breeding Palas. The mean for litter size was at first lambing 1.347±0.036, at the second parity 1.458±0.041, at the third parity 1.587±0.066. The absolute breeding values of sheep at first lambing for litter size were from - 0.073 to 0.122. The relative breeding values for the best sheep were from 115.04 to 136.434. The heritability for litter size in Prolific Breed Palas sheep was 0.080. The estimation of sheep breeding values allows the choice the best sheep for litter size in Prolific Breed Palas sheep for reproduction and the genetic parameters are necessary in the breeding program of sheep breed.

Key words*: breeding values, genetic parameters, individual animal model, number of lambs.*

INTRODUCTION

The animal production depends on productive potential of animals and the number of animals (Grosu, 2019). For increase the quantitative and qualitative production of sheep it is necessary to increase the number of animals. By the breeding of sheep the meat and milk production increase. The breeding value was used for choose the sheep for reproduction.

Reproductive traits have a double importance from a breeding point of view: these traits are economically useful, thus being candidates for inclusion among breeding objectives and the reproductives traits affect the efficiency of selection (Drăgănecu and Grosu, 2003). The prolificacy could be introduced in the objective of artificial selection (Drăgănecu & Grosu, 2003).

Prolific Breed Palas is characterized by high prolificacy producing more than one lamb per birth, often twins and triplets, this breed being important for national sheep industry for improving meat production. By improving the meat production improved the farm profitability. The Prolific Breed Palas could be used for crossbreeding for increase the prolificacy for sheep breeds with low prolificacy.

The litter size was an important economic trait in sheep breeds. The litter size in sheep breed presented variability in different breeds. The environmental factors which influenced the litter size were: the farm management, the age of ewe, the year and season (Grosu et al., 2019). The importance of estimation the genetic parameters for litter size in Prolific Breed Palas was due by the characteristics of the genetic parameters: are specific for each population, are specific for each generation, for each environment. The estimation of genetic parameters was useful for estimation the breeding value of sheep. The most prolific breeds in the world were: Finnish Landrace 300% prolificacy, Romanov 250-300%, Friesian 200-225%, Bluefaced-Leicester 180-200%, Chios-Hu-Yang 200-300%, British Sheep Dary 220-300% (Bulmaga et al., 2021). In Finsheep breed the litter size was between 1-6 lambs, in Romanov 1-5, in Wadi 1-4, in Texel 1-3 lambs (Tao et al., 2021). The methods for sheep flocks were: assisted reproduction, shortening lambing period and deseasonalisation of heat and lambing (Bulmaga et al., 2021). Romania had tradition for sheep breeding. The sheep used the feed at high level. In Romanian sheep breeds, the prolificacy of local breeds was: for Merinos Palas 110-146%, Transylvanian Merinos 112-120%, Spancă 110-116%, Țigaie 104-107%, Țurcană 103-105%, Karakul 105-108% (Taftă,

1997). Teleorman Black Head had a high prolificacy 130-160% (Grosu et al., 2005). The improvement of the reproduction traits was a goal in breeding program of sheep breed. Bradford (1985) reported that the prolificacy has been used as a breeding objective in different breeding schemes despite its low heritability. In a number of breeding programs, genomic selection has been used to assign for litter size (Bolormaa et al., 2017). Crossbreeding of local breeds with Prolific Breed Palas has been the major means of genetically improving prolificacy. The prolificacy will remain an important breeding goal for sheep in local sheep breeds.

Current state of the study of reproduction traits in sheep is focused on genomic selection, the identifying the major genes which are associated with fertility, prolificacy. Inclusion of genetic information of the genes associated with reproductive ability could efficiently enhance the selection response (Abdoli et al., 2016).

For Prolific Breed Palas, it is necessary to estimate the heritability because the heritability is specific for each population, because the genetic components of variance were influenced by the frequence of genes in population and the environmental conditions of the different populations.

Because prolificacy is a trait with low heritability, in order to improve this trait will be more efficiently to select animals based on their genotype, the animals with favorable genotype.

A breeding strategy for improving the prolificacy in Prolific Breed Palas is to select sheep on genomic estimated breeding values. The methodology to estimate genomic breeding values will be Single-Step Genomic Best Linear Unbiased Prediction (ssGBLUP) to increase the accuracy of genetic evaluation of sheep. For the traits with low heritability the use of genotype in breeding values estimation may accelerate the genetic gain for young animals.

The advantage of integration major genes for high prolificacy in a breeding program was the possibility of introgression through crossbreeding, of desired mutations into local breeds which may improve prolificacy and lamb production in a short time (Olivan and Pardos, 2000). In France, England, Norway there were selection schemes for improve the litter size (Perez-Enciso, 1995).

The litter size in sheep could be increased by direct selection (Hanrahan, 1990; Schoenian and Burfening, 1990) but the gains have not been very large because of the low heritability of litter size.

The use of estimated breeding values, using BLUP (Best Linear Unbiased Prediction) methodology will accelerate genetic progress (Jansens et al., 2004).

In the breeding program in Romanian sheep breeds the genetic parameters are needed for the breeding value estimation procedure.

The Prolific Palas Breed was reproductive isolate and was selected in order to increase prolificacy rate. Breeding area of the Prolific Breed Palas was Dobrogea at Research Institute for Sheep and Goat Breeding Palas - Constanta, there are 1000 heads of sheep and 2000 in another farm in the area.

In the breeding program of Prolific Breed Palas, the breeding goal was the improvement the prolificacy this breed was specialized breed for prolificacy (over 150%), breastfeeding capacity and limitation inbreeding below 1% per generation. Breeding method was selection within breed, mating was done by rational matching of pairs by ram families.

The breed was used for increasing the prolificacy of local breeds and producing triracial hybrid lambs to achieve the priority objective of increasing meat production in sheep.

The main goal of making the Prolific Breed Palas is to obtain father rams for the hybrid ewes with high prolificacy rate.

The litter size in sheep production had an important economic value. By using the individual animal model for selection, the best animals with high breeding values increase the genetic progress for prolificacy.

The heritability of prolificacy is important and the heritability for production traits and correlation between reproductive and productive traits for implement a multi-trait index in future selective breeding programme of Prolific Breed Palas. The prolificacy was positive correlated with milk production. Knowledge of the heritability of trait is very important for the theory and practice of breeding. Almost all practical breeding decisions depend on the size of heritability: prioritizing genetic breeding or exploitation improvement in order to increase

production, choosing the breeding system, choosing the selection method, establishing the selection objective. The heritability coefficient enters into all formulas regarding the estimation of genetic progress, as well as into formulas regarding the prediction of breeding value. The heritability is a characteristic of a trait, of a population. The genetic components of variance were influenced by the frequence of genes, different in different populations and the environmental conditions of the different populations. Heritability is a property of each trait is determined by several pairs of genes with different effects.

Ziadi et al. (2024) reported that reliable estimation of genetic parameters for litter size was necessary for reach optimum rate of genetic progress.

The litter size was a trait influenced in great proportion by the environmental factors and a low proportion by genetic factors. In Romania it was necessary to have sheep breeds with high prolificacy. For improving reproduction efficiencies an important role had molecular genetics and marker-assisted selection (Deac et al., 2022). In Romania, at Research and Development Institute for Sheep and Goat Breeding Palas-Constanța was created the Prolific Breed Palas, approved as breed in 2020. The breed was created by crosses between Palas Merino sheep and rams from prolific breeds Romanov, Border Leicester, Ile-de-France, East -Friesian and Finish Landrace (Dordescu et al., 2022). By cross-breeding it was the possibility to improve quickly the prolificacy and lambs' production by incorporate the genes for high prolificacy (Gootwine, 2020).

Prolific Breed Palas had a high prolificacy, in the first lambing 143.43% and 153.80% in multiparous ewes (Dordescu et al., 2022). The total flock of Prolific Palas was 431 sheep (Dordescu et al., 2022). For increase numerical the sheep breed it was necessary to increase the prolificacy. The Prolific Breed Palas had a high milk yield which allow all lambs to be nursed. The Prolific Breed Palas was adapted for the environmental conditions from our country, the ewes are less demanding on feed and more resistant to environmental conditions. In Romania the improvement of meat production depended of reproduction traits. The prolificacy represents the number of lambs obtained from ewes that have lambed (Pascal, 2015). The genetic factors (breed, population, individual) and environmental factors (age of sheep, weight of sheep, nutrition, breeding season, rearing type, feeding level) influenced the prolificacy. Because the prolificacy was influenced by nutrition, it was necessary to assure of sheep and rams' rational feedings. For the profitability of farms must the increase the number of lambs born. By capitalizing on the lambs, increased the profitability of farms. Previous researchers estimated the genetic parameters for litter size in sheep with threshold model and linear animal model (Yadollahi et al., 2018), animal model with repeatability (Schmidova et al., 2014).

Different authors analysed the litter size using different models: repeatability model, multiple trait model, random regression model (Ziadi et al., 2025).

The BLUP (Best Linear Unbiased Prediction) methodology had more advantages: takes into account the sheep's performances data and of its offspring and relatives.

The use of the animal model that use all available sources of information and the average of more lambing can improve the population.

Breeding decisions depend on the size of heritability giving priority to genetic improvement or improving the environmental conditions in order to increase, choosing the breeding system, choosing the selection method, establishing the selection objective. The heritability enters into the formulas regarding the prediction of breeding value (Drăgănescu & Grosu, 2003).

The objective of selection was to obtain maximum genetic progress per unit of time and expense. It must be optimized by establishing several objectives, retaining the one that maximizes the annual genetic gain, with minimal costs. Meat production per female was a complex trait, made up of simpler traits: prolificacy, growth rate and offspring carcass weight. Prolificacy depends on other simple traits, such as ovulation rate. The traits that will be included in the selection objective must be taken into account three criteria: economic importance, heritability and genetic correlation with other traits. Sandu and Drăgănescu (1983) reported that the decision to accept traits in the selection objective is based on the calculation of a global indicator called the competitiveness of

the trait which will cumulate the information provided by the three parameters: economic values, heritability and genetic correlations of traits. Ollivier (1998) reported the relative economic values of production and reproduction traits. For different sheep breeds were developed maternal index. These indexes aim to enhance the efficiency of ewes flocks, making the more productive. Theodoridis et al. (2017) reported that the estimated economic values of the traits revealed their economic impact on the definition of the breeding goal for the specified production system and that milk production and fertility had the highest economic values (€ 40.30 and € 20.28 per standard deviation). The production and reproduction traits, which include milk production, prolificacy and milking speed contributed most to the breeding goal (70%), but functional traits still had a considerable share (30%) (Theodoridis et al., 2017). For realize a breeding program it is necessary to study the economic values of traits. The production and reproduction traits are the traits which can be efficiently treated through genetic improvement and other traits can be improve through managerial intervention. (Theodoridis et al., 2017). In recent studies regarding the litter size were identified the genes (NGF, AKT1, SYCP1) associated with the regulation of the development of oocytes (Tao et al., 2021).

The novelty lies in the fact that the genetic parameters for litter size in Prolific Breed Palas sheep were not estimated. The main pathways for the genetic improvement of livestock are: selection between breeds, crossbreeding and selection within breeds.

The aim of this research was the estimation the breeding values and genetic parameters using individual animal model in Prolific Breed Palas sheep. In the breeding program of Prolific Breed Palas a breeding strategy to improve litter size is the selection within breed, nucleus schemes could be a good strategy for genetic improvement. Also, the genomic selection was a breeding strategy to improve litter size. The heritability of prolificacy and production traits and the correlation between prolificacy and productive traits in Prolific Breed Palas are important for implement a multi-trait index in future breeding program.

MATERIALS AND METHODS

The data used in this study provided from Research and Development Institute for Sheep and Goat Breeding Palas-Constanța. The breeding season was planned for October-November. In the Prolific Breed Palas the ewes had lambs both in spring and throughout the year. The ewes from our study had lambs in winter and spring. The feeding was balanced.

For Prolific Breed Palas sheep breed the pedigree contended 345 sheep: 170 ewes with performances, 131 ewes and 44 rams. In the model were included the following fixed factors: the age at first lambing with 2 levels and the year of birth of ewe with 5 levels. From 229 lambs, 111 were from simple lambing and 118 lambs were from twin birth. The ewes had 65.2% simple lambing and 34.8% twin lambing.

The age of ewe at lambing was between 22 and 27 months for 84.1% from ewes and over 30 months for 15.9% from the total number of ewes with records. The prolificacy was higher for the ewes with age over 30 months, the Student test showed that were not difference signifiant between the means of samples. For year of lambing the Student test showed that were difference signifiant between means of sample ($P<0.05$).

Statistical analysis

The model used was individual animal model (Grosu et al., 2013, 2019) described as follows.

The model was:

$y_{ijk} = Y_i+A_j+a_k+e_{ijk}$

y_{ijk} = was the number of lambs;

Y_i = was the year effect (fixed effect);

A_j= age effect of ewe (fixed effect);

a = was additive genetic effect;

e = was a residual error effect.

The model could be written as:

$y=Xb+Za+e$

X = was the incidence matrices for fixed effects;

Z = was the incidence matrices for additive genetic effects;

y = was the vector of observations;

b = was the vector of the fixed effects;

a = was the vector of the additive genetic effects of sheep;

e= was the vector of error.

The mixed model-like equations were:

$$\begin{pmatrix} X'X & X'Z \\ Z'Z & Z'Z + A^{-1}K \end{pmatrix} \begin{pmatrix} \tilde{b} \\ \hat{a} \end{pmatrix} = \begin{pmatrix} X'Y \\ Z'Y \end{pmatrix}$$

$$k = \frac{1 - h^2}{h^2}$$

The variance components were estimated:

$$\sigma_e^2 = \frac{P'P - \tilde{b} * X' * P - \hat{a}' * ZP}{n - r(X)}$$

σ^2_e= was the residual variance

where:

r(x)= was the rank of matrix X which was the number of linearly independent columns, known as a degree of freedom for fitting the fixed effects of the model.

$$\sigma_a^2 = \frac{\hat{a}' * A^{-1} * \hat{a} + \sigma_e^2 * tr(A^{-1} * C_{22})}{q}$$

σ^2_a = was the additive genetic variance

where:

C_{22} = was the sub-matrix corresponding to random effects in the system of equations which was obtained after reversed throughout the system of equations:

$$C = \begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1} * k \end{bmatrix}^{-1} = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix}$$

The heritability for reproduction traits was estimated as:

$$h^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_e^2}$$

where:

h^2 = the heritability;

σ^2_a = was the additive genetic variance;

σ^2_e = was the residual variance.

The relative breeding value was:

$$BV\% = 100 + 12 * (\frac{BV_{abs} - Average\ BV_{abs}}{\sigma_{BVabs}})$$

BV% = relative breeding value;

BV_{abs} = absolute breeding value;

σ_{BVabs} = standard deviation of absolute breeding values.

RESULTS AND DISCUSSIONS

The number of lambs was important for profitability of flock in sheep breeds.

The mean for number of lambs was influenced by sheep breed. The number of lambs was influenced by maternal ability of sheep, the age of ewe, the year of calving. The milk yield in Prolific Breed Palas was 160-180 kg. The level of improvement and the degree of precocity of the breeds are correlated with the particularity of the breeds to show heat in several seasons (Pascal, 2015)

In the Table 1 were presented the statistics for number of lambs born in Prolific Breed Palas sheep in the first, second and third parity.

Table 1. The descriptive statistics for number of lambs born

Specification	Number of lambs born (first lambing)	Number of lambs born (second lambing)	Number of lambs born (third lambing)
Mean ± Standard error mean	1.347±0.036	1.458±0.041	1.587±0.066
Standard deviation	0.477	0.499	0.527
Number of ewes	170	142	63

The number of lambs born in Prolific Breed Palas breed was higher in second and third lambing than in first lambing. For the survival of lambs, it was necessary to assure optimal microclimate conditions. Prolific Breed Palas was a breed with good precocity, the young ewes could be introducing at reproduction at 7-9 months and the rams at 7-10 months (Stanciu, 2013). For young rams from the Prolific Breed Palas, Stanciu et al. (2013), reported a fecundity of 66.66-83.33% and a prolificacy of 100-122.22%, the young sheep of the Prolific Breed Palas the fecundity was 81.25% and the prolificacy 115.38%. The young ewes and young rams must to have a body weight represented 60-70% from adult sheep weight at Merinos sheep and 50-60% at prolific breeds and meat breeds sheep (Pascal, 2015). In breed sheep the reproductive process was determined by the genotype/environment interaction represented by daylight hours, temperature, humidity (Pascal, 2015). The reproduction traits depended on the farm management. The farmers organized breeding and lambing campaigns in optimal periods (Pascal, 2015). By high litter size increased in the total herd. Sharafeldin (1960) reported that the age of ewe influenced the percentage of multiple births which increased with the age of the ewe, the largest

percentage of single, twin and triplet birth was for two-, five- and six- year- old ewes. The primiparous sheep had lower prolificacy than multiparous ewes. The nutritional conditions of ewe influenced the fertility of ewe (Sharafeldin, 1960). Bulmaga et al. (2021) reported that the ewes with higher weight had higher prolificacy than the ewes with lower weight in Merinos Palas which had lower prolificacy. Pascal (2015) reported that the intensity of reproduction activity was higher in autumn season for sheep from temperate climate and that breeds as Dorset, Merinos Rambouillet, Polipay, Finish Landrace, Romanov were less exposed to seasonal influences on reproductive behaviour. For increase the profitability of farms, the farmers must know the particularities of sheep breeds for reproduction activity, reproductive biotechnologies could be applied to allow staggered parturition (Pascal, 2015). The demand for lambs' production was higher in spring in our country, fattened young and adult sheep were demanded in the foreign market.

The mean value for litter size was lower in Prolific Palas in first, second lambing and third lambing from our study than the mean obtained by Ziadi et al. (2025) reported the mean for litter size for prolific line in Tunisian Barbarine 1.43±0.57 in the first parity, 1.49±0.60 in the second parity and 1.63±0.62 in third parity. In our study the means for litter size was higher in the first three lambing than in conventional line in Tunisian Barbarine the mean was 1.08±0.28 in first parity, 1.07±0.25 in second parity and 1.06 in the third parity.

The mean for litter size in our study was closed to the value reported by Altarriba et al. (1998) for litter size of 1.35±0.48 in the Rasa Aragonesa.

Ben Salem et al. (2009) reported a lower mean of 1.32±0.47 in Noire de Thibar breed sheep than in our study. Habtegiorgis et al. (2022) reported a higher mean than in our study of 1.57 for number of lambs in Doyogena sheep.

De Vries et al. (1998) reported a mean of 1.64 for Zwartbles in first parity, 2.12 in second parity and 2.31 in third parity. The mean for number of lambs born was 1.318 in Polish Merino (Piwczynski et al., 2011).

Bromley et al. (2000) reported the mean for litter size born 1.61 in Columbia, 1.84 in Polypay, 1.63 in Rambouillet and 1.58 in Targhee.

The absolute breeding values for litter size in Prolific Breed Palas were presented in the Table 2.

Table 2. The highest absolute breeding values for litter size in Prolific Breed Palas sheep

No.	The absolute breeding values
1	0.122
2	0.121
3	0.117
4	0.108
5	0.104
6	0.100
7	0.098
8	0.068
9	0.061
10	0.058

The highest absolute breeding values for litter size in Prolific Breed Palas were between 0.058 and 0.122. The breeding values allowed to select sheep about the genetic merit.

In the Table 3 were presented the highest breeding values for litter size in Prolific Breed Palas.

Table 3. The highest relative breeding values for litter size in Prolific Breed Palas sheep

No.	The relative breeding values
1	136.434
2	136.100
3	134.763
4	131.754
5	130.417
6	129.080
7	128.412
8	118.384
9	116.044
10	115.041

The breeding value allowed estimate the genetic potential of sheep for litter size. The relative breeding values for the best sheep for litter size had the values between 115.041 and 136.434. In the sheep population there were individuals with higher prolificacy. Litter size could be improved by selection of the best sheep with the highest breeding values. By using the breeding values of sheep's, the selection lead quickly improvement

the sheep population and to achieve genetic progress. Selection using breeding values will lead to faster rates of genetic gain and flock improvement than selection based on raw data. A ram with a breeding value +0.20 produced daughters that will produce 10% more lambs than a ram with the breeding value 0.

In the Table 4 was presented the heritability for litter size in Prolific Breed Palas.

Table 4. The genetic parameters for litter size in Prolific Breed Palas

Item	Heritability
Litter size at birth	0.080±0.236

The heritability value of a trait shows us how much of the observed differences between the performances of individuals in the population are expected to be caused by difference between their breeding values.

The heritability for litter size in Prolific Breed Palas was low. The multi-trait index for milk production and prolificacy could be implemented in the breeding program of Prolific Breed Palas. The heritability could be influenced by the different environmental conditions from sheep flocks. Janssens et al. (2004) reported the heritability for litter size in sheep ranged from 0.06 to 0.13. De Vries et al. (1998) reported heritability for litter size in two prolific sheep, with repeatability model was 0.10 for Zwartbles and 0.12 for the Swifter and for multivariate model in first, second and third parity was 0.05, 0.07 and 0.10 for Zwartbles and 0.09, 0.12 and 0.09 for Swifter. De Vries et al. (2005) reported heritability for the total number of lambs born in German sheep breeds between 0.06 and 0.07.

Ziadi et al. (2025) reported heritability for litter size in Tunisian Barbarine sheep ranged from 0.04 to 0.18 for the prolific line and from 0.17 to 0.39 for the conventional line.

Piwczynski et al. (2011) reported the heritability for number of lambs born 0.25 and 0.29 estimated with a linear model and 0.054 estimated with threshold model. The heritability from our study was closed with the heritability found by Poutahmasebian et al. (2021) in Afshari sheep breed. Murphey and Thomas (2017) reported heritability for number of lambs born 0.07. Also, Sousa et al. (2000) reported the heritability 0.07 for the number of born lambs.

Murshedi et al. (2023) reported the heritability for prolificacy in Palas Prolific Line sheep was 0.177 higher than in our study.

Murshedi et al. (2024) reported heritability for prolificacy 0.235 in Palas Milk Line sheep population. The heritability for litter size in Rambouillet with linear sire model 0.16 and in Finnsheep 0.06, with animal model 0.16 in Rambouillet and 0.08 in Finnsheep, and with threshold sire model was 0.45 in Rambouillet and 0.14 in Finnsheep, and with threshold animal model 0.25 in Rambouillet and in Finnsheep 0.13 (Matos et al., 1997).

The heritability for litter size at birth in Columbia breed sheep was 0.12, in Polypay 0.12, Rambouillet 0.14, Targhee 0.01 (Okut et al., 1999). Bromley et al. (2000) reported that the heritability ranged from 0.3 to 0.11 for prolificacy traits (litter size at birth and litter size at weaning). Hanford et al. (2003) reported direct heritability 0.10 for litter size at birth and 0.07 for litter size at weaning in Targhee breed sheep.

The prolificacy influenced in a great proportion the economic efficiencies of sheep flocks. By genetic evaluation of sheep allowed to separate the influence of genetics from environmental factors.

The intensification of reproduction could be achieved by: increasing reproduction rates, early use young ewe for reproduction, organizing frequent lambing, practicing crossbreeding with prolific breeds in order to increase the reproduction rates, synchronizing the sexual cycle and grouping lambing (Pascal, 2015).

Grosu & Oltenacu (2005) reported that demographic and selection parameters together with genetic and phenotypic parameters of the selection traits determine the genetic gain achieved. The traits included in the selection objective must be chosen on economic criteria, with priority given to those that have economic importance.

Legarra et al. (2006) reported the median of the estimated economic weight for fertility, prolificacy, milk yield and longevity were 138.60 € per lambing, 40 € per lamb, 1.18 € per l, 1.66 € per year in Latxa breed and 137.66 € per lambing, 34.17€ per lamb, 0.73€ per l, 2.10 € per year for Manchega breed, consider that the fertility must include in the breeding program of sheep breed.

In the breeding program of Prolific Breed Palas a breeding strategy to improve litter size can be the nucleus schemes. Grosu & Oltenacu (2005) reported the selection plan for improvement the prolificacy was elaborate by King- the King program and that annual genetic gain was 0.03 lambs/year/ewe or 1.07% on year. The genetic gain represented the ratio between product (between heritability of the litter size and selection intensity) and generation interval. Kosgey (2004) reported that the selection of rams was realized with the criteria applied: number of lambing per year, litter size, viability of the lambs, live weight of lambs at 30 days of age and 70 days, and body conformation and the selection of ewes with the criteria applied: litter size and nursing ability. The dissemination of selected sheep is organized by the Breeding association and consists of young rams from the station and the ewes from the elite farms. The selection base remains open for include new farmers and new breeding sheep in the population under selection. The success of this program was done by the professional structure represented by Breeder's association for the management, active technical extension services and financial support (Kosgey, 2004).

Safari et al. (2005) reported that using within-breed selection in sheep the annual genetic gain was 1-2% for prolificacy, because this trait had a low heritability.

For Prolific Palas Breed will estimate a genetic gain for prolificacy will be 1.02% or 0.014 lambs/year/ewe.

We propose a breeding strategy which selection the animals by genomic breeding values. For estimating the genomic breeding value used three information sources: phenotypic informations (litter size at lambing), pedigree information (kinship between animals), genomic informations (SNP- single nucleotide polymorphism).

The model for estimation the genomic breeding value could be:

$$y_{ij} = B_i + a_j + e_{ij}$$

y_{ij} = litter size;

B_{ij} = the fixed effect;

a_j= the random effect for genetic effect;

e_{ij} = residual error.

The methodology to estimate genomic breeding values will be Single-Step Genomic Best Linear Unbiased Prediction (ssGBLUP) to increase the accuracy of genetic evaluation of Prolific Breed Palas sheep. The biometric model for estimation the genomic breeding values was realised by Misztal et al. (2009):

$$\begin{bmatrix} X' \cdot X & X' \cdot Z \\ Z' \cdot X & Z' \cdot Z + \alpha \cdot H^{-1} \end{bmatrix} \cdot \begin{bmatrix} \tilde{b} \\ \hat{a} \end{bmatrix} = \begin{bmatrix} X' \cdot y \\ Z' \cdot y \end{bmatrix}$$

$$H^{-1} = A^{-1} + \begin{bmatrix} 0 & 0 \\ 0 & G^{-1} - A_{22}^{-1} \end{bmatrix}$$

H = is the matrix which combined the genealogic information from pedigree (by A) with genomic information (by G).

The formula for genetic gain is (Grosu et al., 2019):

$$\Delta G = \frac{r_{A,I}}{T} \sigma A$$

ΔG = genetic gain;

$r_{A,I}$ = the accuracy of genetic evaluation;

T = the interval between generations;

σ_A = additive genetic variance.

The simulation selection scheme (Martin et al., 2025) will be used for Prolific Palas Breed was:

1) First step - The mating of rams with ewes (the sex ratio 1 ram/30 ewes)
2) Second step - Obtained the lambs males and females which will be genotyped all
3) Third step – the lambs were phenotyping and selected in proportion of 2% for males and 20% for females as future breeding rams and respectively future breeding ewes.

   Natality - 1.5 lambs/ewe

   Survival - 0.9

   1) 34 rams x 1000 ewes (mating)
   2) 1350 lambs

      675 lambs males + 675 lambs females will be genotyped
   3) 14 future breeding rams +135 future breeding ewes

Martin et al. (2025) reported in their simulate on study that the genetic gain increased with increasing the number of genotyped lambs and was more beneficial when heritability was low and that genotyping all the animals maximizes the genetic gain and accuracy of the breeding values.

In the breeding program of sheep, the genomic selection offers the possibility to farmers for

identify to early age the animals with high breeding values the effect was the increase the yearly genetic gain. The genetic gain depends on the accuracy of genetic evaluation, the intensity of selection, the interval between generations and the additive genetic effect (genetic variability) of the trait (Grosu et al., 2019). In genomic selection the accuracy of genetic evaluation depends on the precision of the estimation of effect of single nucleotide polymorphism and the relationship between SNP markers and genes which control the trait. The precision of estimation of SNP effects depends on the size of the reference population and the heritability of the prolificacy trait. By genomic selection, the number of candidates to selection increase, the proportion of the individual retained for reproduction decreases and the intensity of selection increases. The main advantage of genomic selection was that the parents of next generation will be selected at very early age, the selection can be realized after birth and reduced the generation interval. (Grosu et al., 2019).

CONCLUSIONS

The Prolific Breed Palas could be used for crossbreeding for increase the prolificacy for sheep breeds with low prolificacy. The genetic parameters for litter size in Prolific Breed Palas were necessary for reach optimum rate of genetic progress.

The heritability for litter size in Prolific Breed Palas population was low. In the selection of sheep, the BLUP methodology, individual animal model was a good method for the genetic evaluation of the sheep. By selection of the best sheep will increase the genetic gain. The multi-trait index for milk production and prolificacy could be implemented in the breeding program of Prolific Breed Palas. A good management could improve the reproduction traits by ensuring optimal nutrition and good microclimate conditions. The purpose of this paper was to present a methodology for estimating breeding values and genetic parameters for this breed that can be used in a breeding program that will be carried out by sheep breeder associations. For Prolific Palas Breed will estimate a genetic gain for prolificacy will be 1.02% or 0.014 lambs/year/ewe.

We propose a breeding strategy which selection the animals by genomic breeding values. For estimating the genomic breeding value used three information sources: phenotypic informations (litter size at lambing), pedigree information (kinship between animals), genomic informations (SNP- single nucleotide polymorphism).

ACKNOWLEDGEMENTS

This work was supported by funds from the National Research Projects 8.1.2 and 8.1.3 granted by the Romanian Ministry of Agriculture and Rural Development and from Romanian Breeding Association for Beef cattle, Support project Climate Smart Advisors PN-IV-P8-8.1-PRE-HE-ORG-2025-0256, Project Support Climate Farm Demo PN-IV-P8-8.1-PRE-HE-ORG-2025-0258.

REFERENCES

Abdoli, R., Zamani, P., Mirhoseini, S.Z., Hossein-Zadeh, N.G., & Nadri, S. (2016). A review on prolificacy genes in sheep. *Reproduction in Domestic Animals*, 1-7.

Altarriba, J., Varona, L., Garcia-Cortés, L.A., & Moreno, C. (1998). Bayesian inference of variance components for litter size in rasa Aragonesa sheep. *J. Anim. Sci.*, 76, 23-28.

Ben Salem, I., Rekik M., Hammami, H., Hamouda, M.B., Aloulou, R., & Saadoun, L. (2009). Facteurs de varation non genetique de la productivite des brebis de race Noire de Thibar. *Revue Elev. Med. Vet. Pays Trop.*, 6211, 59-66.

Bolormaa, S., Brown, D.J., Swan, A.A., Van der Werf, J.H.J., Hayes, B.J., & Daetwyler, H.D. (2017). Genomic prediction of reproduction traits for Merino sheep. *Anim. Genet*., 48, 338-48.

Bradford, G. (1985). *Selection for litter size*, in: Land, R.B., Robinson, D.W. (Eds.), Genetics of Reproduction in Sheep. London, UK: Butterworths, 3–18.

Bromley, C.M., Snowder, G.D., & Van Vleck, L.D. (2000). Genetic parameters among weight, prolificacy and wool traits of Columbia, Polypay, Rambouillet and Targhee sheep. *J. Anim. Sci.,* 78, 846-858.

Bulmaga, V.D., Raducuță, I., Cristian, C., & Călin, I. (2021) Methods and technologies used to increase the prolificacy of local sheep breeds. *Scientific Papers, Series D. Animal Science*, LXIV(1), 299-305.

De Vries M.J., Van der Waaij, E.H., & Van Arendonk, J.A.M. (1998). Estimation of genetic parameters for litter size in sheep: a comparison of a repeatability and a multivariate model. *Animal Science*, 66, 685-688.

De Vries, F., Hamann, H., & Distl, O. (2005). Genetic parameter for reproduction traits in land sheep breedes. *Arch. Tierz.,* 48, 76-85.

Deac, A.M., Muscă, A.S., Aipătioaie, M.G., Coșier, V., & Zăhan, M. (2022). Methods of improving reproductive parameters in sheep and the major genes associated with prolificacy: a review. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies, 79, 1, 7-27.*

Dordescu, O. C., Vicovan, P.G., Raducu, R., Vicovan, A., Vartic, A. G., Stanciu, M., & Creanga, S. (2022). Analysis of the genetic history of the Prolific Palas breed. *Animal and Food Sciences Journal* Iasi, 9-13.

Drăgănescu, C., & Grosu, H. (2003). *The breeding of animal,* Course. Bucharest, RO: Agrotehnica Publishing House.

Gootwine, E. (2020) Invited review: opportunities for genetic improvement toward higher prolificacy in sheep. *Small Rumin. Res.*, 186, 106090.

Grosu, H., & Oltenacu, P.A. (2005). *The breeding programs in Animal Husbandry.* Bucharest, RO: Ceres Publishing House.

Grosu, H., Drăgănescu, C., & Joițoiu, R. (2005). *The Romanian Carabash breed (Romanian Ruda with Black Head)*. Rm. Vâlcea, RO: Conphys Publishing House.

Grosu, H., Schaeffer, L., Oltenacu, P.A., Norman, D., Powell, R., Kremer, V., Banos, G., Mrode, R., Carvalheira, J., Jamrozik, J., Draganescu, C., & Lungu, S. (2013). *History of genetic evaluation methods in dairy cattle*. Bucharest, RO: The Publishing House of the Romanian Academy.

Grosu, H., Lungu, S., Oltenacu, P.A., Drăgănescu, C., & Mateescu, R. (2019). *The prediction of the breeding value in cattle.* Bucharest, RO: Ceres Publishing House.

Korsgay, I. S. (2004). *Breeding objectives and breeding strategies for small ruminants in the tro*pics. Ph. D. Thesis, Wageningen University.

Hanrahan, J.P. (1990) Effect of selection for increased litter size on ovulation rate and embryo survival in sheep. *Br. Soc. Anim. Prod. Winter Meet*, Paper 32.

Jansens, S., Vandepitte, W., & Bodin, L. (2004). Genetic parameters for litter size in sheep: natural versus hormone-induced oestrus. *Genet. Sel. Evol*., 36, 543-562.

Habtegiorgis, K., Haile, A., Getachew, T., Jimma, A., & Gemiyo, D. (2022). Litter size, litter weight , and lambs survivability of Doyogena sheep managed under community- based breeding program in Ethiopia. *Helion*, 8.e11576. https://doi.org/10.1016/j.heliyon.2022.e11576

Hanford, K.J., Van Vleck, L.D., & Snowder, G.D. (2003). Estimates of genetic parameters and genetic change for reproduction, weight, and wool characteristics of Targhee sheep. *J. Anim. Sci.,* 81, 630-640.

Legarra, A., Ramon, M., Ugarte, E., & Perez-Guzman, M.D. (2007). Economic weight of fertility, prolificacy, milk yield and longevity in dairy sheep. *Animal*, 1, 193-203.

Martin, R., Pook., T., Bennewitz, J., & Schmid, M. (2025) Genome selection strategies for the German Merino sheep breeding -A simulation study. *Journal Animal Breeding*, 142, 251-262.

Matos, C.A.P., Thomas, D.L., Gianola, D., Tempelman R.J., & Young, L.D. (1997a). Genetic analysis of discrete reproductive traits in sheep using linear and nonlinear models: I Estimation of genetic parameters. *J. Anim. Sci.,* 75, 76-8.

Matos, C.A.P., Thomas, D.L., Gianola, D., Perez-Enciso, M., & Young, L.D. (1997b) Genetic analysis of discrete reproductive traits in sheep using linear and nonlinear models: II Goodness of fit and predictive ability. *J. Anim. Sci.,* 75, 88-94.

Misztal, I., Legarra, I., & Aguilar I. (2009). Computing procedures for genetic evaluation including phenotypic, full pedigree, and genomic information. *Journal of Dairy Science*, 92, 4648-4655.

Murphy, T. W., Berger Y.M., Holmen P.W., Baldin M, Bergett R.L., & Thomas, D. L. (2017). Estimates of genetic parameters, genetic trends, and inbreeding in a crossbred dairy sheep research flock in United States. *J. Anim. Sci.*, 95, 4300-4309.

Murshedi, O.M.A., Grosu, H., & Paraschivescu, P.L. (2023). Estimation of the heritability for production and reproduction traits in the Palas-Prolific Line Sheep, using BLUP methodology. *Scientific Papers. Series D. Animal Science*, LXVI(2), 70-74.

Murshedi, O.M.A., Grosu, H., & Paraschivescu, P.L. (2024). Comparative analysis of procedures for predicting breeding value for traits of economic importance in a sheep population. *Scientific Papers. Series D. Animal Science*, LXVII(2), 45-53.

Okut, H., Bromley, C.M., Van Vleck, L.D., & Snowder, G.D. (1999). Genotypic expression at different ages: I Prolificacy traits of sheep. *J Anim Sci* 77, 2357-2365.

Oliván A., Pardos L. (2000). Importance of a sheep selection programme for prolificacy. In: Gabiña D. (ed.). Analysis and definition of the objectives in genetic improvement programmes in sheep and goats. An economic approach to increase their profitability. Zaragoza, CIHEAM, 93-100 (Option Méditerranéennes, Série A., Séminaires Méditerranéens, 43)

Ollivier, L. (1998). Genetics of Pigs. Ruvinsky Ed. N.Y.

Pascal C. (2015). Treaty on breeding sheep and goats. Publishing House Ion Ionescu de la Brad, 2015.

Pérez-Enciso, M., Foulley, J., Bodin, L.,Elsen J.M., Poivey J.P. (1995). Genetic improvement of litter size in sheep. A comparison of selection methods. *Genetics Selection Evolution*, 27, 1, 43-61.

Piwczynski, D., Kowaliszyrr, B., Mroczkowski, S. (2011). Heritability and repetability of the number of lambs born and reared estimated using linear and threshold models. *Archiv Tierzucht*, 54, 3, 271-279.

Pourtahmasebian Ahrabi, M., Eskandarinasab, M. P., Bagher Zandi Baghcheh Maryam, M. (2021). Genetic parameters estimation of prolificacy traits under the FecB introgression pressure in Afshari sheep breed. *Iranian Journal of Applied Animal Science*, 11, 2, 329-337.

Sandu, G., Draganescu, C. (1983). Biological efficiency of traits and selection indices in a paternal line of pigs. *Scientific Papers I.A.N.B*., series D, XXVI, Bucharest.

Sharafeldin M.T. (1960). Factors affecting litter size in Texel sheep. Mededelingen Van de

Landbouwhogeschool Te Wageningen, Nederland, 60, 3, 1-61.

Schmidova, J., Milerski, M., Svitakova, A., Vostry, L., Novotna, A. (2014). Estimation of genetic parameters for litter size in Charolais, Romney, Merinolandshaf, Romanov, Suffolk, Sumava and Texel breeds of sheep. *Small Ruminant Research*, 119, 33-38.

Schoenian, S.G., Burfening, P.J. (1990). Ovulation rate, lambing rate, litter size and embryo survival of Rambouillet sheep selected for high and low reproductive trait. *J Anim Sci* , 68, 2263-2270

Sousa, W.H., Pereira, C.S., Bergmann, J.A.G., Da Silva. F.L.R. (2000). Estimates of components of variance and genetic parameters for reproductive traits by means of linear and threshold models. *Rev. Bras. Zoot.,* 29, 2, 2237- 2247.

Safari, E., Fogarty, N.M., & Gilmour, A.R. (2005). A review of genetic parameter estimates for wool, growth, meat and reproduction traits in sheep. *Livest. Prod. Sci*. 92, 271–289. https://doi.org/10.1016/j.livprodsci.2004.09.003

Stanciu, M., Zamfir, C.Z., Enciu, A., Nicolescu, A. Sauer, M., & Pivodă, C.A. (2013). The precocious use of sheep and goat youth at reproduction. *Scientific Papers, Animal Sciences*, 59, 42-47.

Taftă, V., Vintilă, I., & Zamfirescu, S. (1997). *Production, breeding and reproduction of sheep*. Bucharest, RO: Ceres Publishing House.

Tao, L., He, X., Wang, X., Di, R., & Chu, M. (2021). Litter Size of Sheep (*Ovis aries*): Inbreeding Depression and Homozygous Regions. *Genes*, 12, 109. https://doi.org/ 10.3390/genes12010109.

Theodoridis, A., Ragkos, A., Rose, G., Roustemis, D., & Arsenos, G. (2018). Defining the breeding goal for a sheep breed including production and functional traits using market data. *Animal*, 12, 7, 1508-1515.

Yadollahi, S., Gholizadeh, M., & Hafezian, H. (2018). Bayesian inference on genetic parameters for some reproductive traits in sheep using linear and threshold models, *Small Ruminant Research*, https://doi.org/10.1016/j.smallrumres.2018.12.001

Ziadi, C., Bedhiaf Romdhani, S., & Molina, A. (2024). Estimation of Genetic Parameters for Litter Size and Growth Traits in a Prolific Line of Tunisian Barbarine Sheep. *Ruminants,* 4, 256–266.

Ziadi, C., Serradilla, J.M., Romdhani, S.B., & Molina, A. (2025). Genetic analysis of litter size across parities in Prolific and Conventional population of Tunisian Barbarine sheep using random regression model. *Animals*, 15, 638, https: //doi.org//10.3390//ani 5050638.