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THE INFLUENCE OF PARAGENETIC FACTORS ON LAMB BIRTH WEIGHT AND PRE-WEANING GROWTH IN SJENIČKA PRAMENKA

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Abstract: The investigation of the influence of paragenetic factors (farm, year of birth of the ewes, birth order, type of lambing, sex, as well as the interaction between farm and year of birth and between farm and birth order) on lamb body weight at birth and at 30 and 90 days of age was conducted on 268 ewes of the Sjenička Pramenka breed distributed across three farms in the municipality of Gornji Milanovac, born in the period from 2015 to 2023. The study of lamb growth during the suckling period (birth weight and body weight at 30 and 90 days of age) was carried out on a total of 1,399 lambs. Farm, type of lambing, sex of lambs, the interaction between farm and year of birth, as well as the interaction between farm and birth order had a highly significant effect ($P<0.01$) on lamb body weight at birth and at 30 and 90 days of age. Year of birth had a highly significant effect ($P<0.01$) only on lamb body weight at 30 days of age, while birth order had no significant effect ($P>0.05$) on birth weight, but had a highly significant effect ($P<0.01$) on body weight at 30 and 90 days of age. The coefficients of determination were highly significant ($R<0.01$), amounting to 0.273 (27.3%) for birth weight, 0.400 (40.0%) for body weight at 30 days of age, and 0.127 (12.7%) for body weight at 90 days of age.

Keywords: Sjenička Pramenka, lamb, growth rate, body weight, suckling period

Introduction

Sheep farming in Serbia occupies an unfavorable position in terms of productivity, despite the country's natural resources and long-standing tradition. As a branch of livestock production, it is most widespread in hilly and mountainous regions of Serbia, and somewhat less represented in lowland areas. It accounts for about 3.5% of the total value of livestock production. Extensive, semi-extensive, and semi-intensive production systems predominate, while intensive

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sheep production systems are considerably less common. However, the Sjenica sheep, also known as the Vasojevići sheep, is bred over a wider area of western Serbia, the eastern parts of Bosnia and Herzegovina, and the northern part of Montenegro.

Over the past 50 years, sheep meat production has shown an upward trend, increasing from 18 thousand tons in 1970 to 31 thousand tons recorded in 2023 (Statistical Office of the Republic of Serbia). The production of sheep meat, and particularly lamb meat, is greatly influenced by numerous endogenous and exogenous factors.

Phenotypic variations are determined by many factors that can conditionally be divided into two main groups: discontinuous and continuous. The general characteristic of discontinuous or fixed effects is that they cause more pronounced variations in production, reproductive, and functional traits, and can be clearly divided into classes characterized by their own means and variances. This group includes the effects of genotype, farm or breeding area, year and season of lambing and birth, birth order (i.e., age of the dam), type of birth, sex of lambs, etc.

The general characteristic of continuous effects is that they have a certain direction and intensity of action (trend). The most important continuous effects include the genetic influence of the sire, age at first mating and lambing, duration of lactation, length of the service period, etc.

Materials and methods

The effect of fixed systematic factors such as farm, year of birth, birth order, type of lambing, sex of lambs, as well as the interaction between farm and year of birth and between farm and birth order, on lamb growth during the suckling period (body weight at birth, at 30 and 90 days of age, i.e., at weaning) was analyzed in 268 ewes of the Sjenička Pramenka breed distributed across three farms (Farm 1 – 83, Farm 2 – 107, and Farm 3 – 78) in the municipality of Gornji Milanovac, born in the period from 2015 to 2023.

The study of lamb growth during the suckling period (birth weight and body weight at 30 and 90 days of age) was conducted on a total of 1,399 lambs, namely 470 lambs on Farm 1, 506 on Farm 2, and 423 on Farm 3, based on data from the official breeding records of the basic selection service "Velja Farma MAT" D.O.O. from Gornji Milanovac.

Statistical analysis was used to examine the systematic effect of fixed paragenetic factors on birth weight and body weight at 30 and 90 days of age, i.e., on lamb growth during the suckling period:

- **Farm:** Farm I, Farm II, and Farm III.
- **Year of birth:** Group 1 (ewes born from 2015 to 2017), Group 2 (ewes born from 2018 to 2020), and Group 3 (ewes born from 2021 to 2023).
- **Birth order:** Group 1 (first lambing), Group 2 (second lambing), Group 3 (third lambing), Group 4 (fourth lambing), Group 5 (fifth lambing), and Group 6 (sixth and subsequent lambings).
- **Type of lambing:** Group 1 (single lambs) and Group 2 (twins).
- **Sex of lambs:** Group 1 (male lambs) and Group 2 (female lambs).
- ***nteraction between farm and year of birth of the ewe*** (3 farms × 3 groups of ewe birth years), and
- ***Interaction between farm and birth order*** (3 farms × 6 birth order groups).

The analysis of the influence of systematic environmental factors on lamb growth during the suckling period was performed using the General Linear Model (GLM) procedure in the statistical software package SAS (SAS, 2005), according to the following model:

$$\mathbf{y}_{ijklm} = \mu + \mathbf{F}_i + \mathbf{Gr}_j + \mathbf{Jr}_k + \mathbf{Tj}_l + \mathbf{Pj}_m + \mathbf{FTj}_{il} + \mathbf{FJr}_{ik} + \mathbf{e}_{ijklm}\text{,,}$$ gde je:

$\mathbf{y_{ijklm}}$ – individual of the i-th breeding area, the j-th year of birth, the k-th lamb, the l-th type of lamb and the m-th gender of lambs.

μ – the general average of the population with equal representation of all classes of influence (O, Gr, J, Tj, Pj, OpTj),

$\mathbf{Op_i}$– fixed effect of the ith farm (1-3),

$\mathbf{Gr_j}$– fixed influence of the jth year of birth (1-3),

$\mathbf{Jr_k}$– fixed influence of the kth lamb in order (1-6),

Tjl – fixed influence of the lth type of lambing (1-2),

$\mathbf{Pj_m}$– fixed influence of the mth sex of the lambs (1-2),

$\mathbf{OpTj_{il}}$– fixed effect of the interaction of i-th farm (1-3) and j-th year of birth (1-3),

$\mathbf{FJr}_{ik}$ - fixed effect of the interaction of the i-th farm (1-3) and the k-th lamb in the row (1-6),

$\mathbf{e_{ijklm}}$– other undetermined influences..

Results and discussion

The results of the analysis of the influence of systematic factors (breeding area, year of birth, lambing per order, lamb type, lamb gender, interaction of farm and year of birth of sheep as well as interaction of farm and lambing per

order) on the growth of lambs in the lower period, i.e. their birth weight, at 30 and 90 days, i.e. least squares means (LSM), standard errors of the means (SELSM), significance of the observed influences and coefficients of determination are shown in Table 1.

Table 1. Least squares means, standard errors of the means, significance of the observed systematic influences and coefficients of determination for the mass of lambs at birth, at 30 and 90 days

Systematic influences		***Mass at birth(kg)***		***Mass with 30 days (kg)***		***Mass with 90 days (kg)***	
	N	**LSM**	**SE_{LSM}**	**LSM**	**SE_{LSM}**	**LSM**	**SE_{LSM}**
Farm							
Farma I /Farm I	470	$3,05^{b}$	0,024	$10,64^{b}$	0,073	$25,17^{a}$	0,153
Farma II /Farm II	506	$3,19^{a}$	0,023	$9,90^{c}$	0,068	$24,66^{b}$	0,143
Farma III /Farm III	423	$2,96^{c}$	0,028	$11,99^{a}$	0,083	$25,42^{a}$	0,174
F_{exp}		**		**		**	
Birth Year							
I (2015-2017)	535	3,07	0,021	$11,28^{a}$	0,063	25,04	0,133
II (2018-2020)	642	3,04	0,018	$10,71^{ab}$	0,054	24,88	0,114
III (2021-2023)	222	3,10	0,033	$10,54^{b}$	0,100	25,33	0,210
F_{exp}		ns		**		ns	
The age of the mother							
I (*First)*	292	3,05	0,026	$11,18^{a}$	0,079	$24,46^{c}$	0,166
II (*Other)*	293	3,05	0,025	$10,95^{b}$	0,075	$24,74^{c}$	0,158
III (*Third)*	213	3,04	0,030	$10,69^{cd}$	0,091	$24,62^{c}$	0,192
IV (*Fourth)*	193	3,07	0,033	$10,86^{bc}$	0,098	$25,30^{b}$	0,206
V (*Fifth)*	155	3,12	0,036	$10,75^{bcd}$	0,108	$25,82^{a}$	0,227
VI(*sixth and <*)	253	3,09	0,030	$10,64^{d}$	0,091	$25,56^{ab}$	0,192
F_{exp}		ns		**		**	
Lamb type							
I (*Ones)*	1049	$3,24^{a}$	0,015	$11,24^{a}$	0,046	$25,52^{a}$	0,096
II (*Twins)*	350	$2,90^{b}$	0,024	$10,45^{b}$	0,073	$24,64^{b}$	0,153
F_{exp}		**		**		**	
Half a lamb							
I (*Male)*	639	$3,18^{a}$	0,020	$11,04^{a}$	0,059	$25,24^{a}$	0,124
II (*Female)*	760	$2,95^{b}$	0,018	$10,65^{b}$	0,055	$24,93^{b}$	0,116
F_{exp}		**		**		**	
Farm x Birth Year							
I	**I**	209	$2,95^{ef}$	0,030	$10,78^{c}$	0,091	$24,34^{f}$	0,191
I	**II**	177	$2,98^{e}$	0,034	$10,36^{d}$	0,098	$25,47^{bc}$	0,207
I	**III**	84	$3,23^{a}$	0,052	$10,78^{cd}$	0,155	$25,72^{b}$	0,326

II	**I**	238	$3,21^{ab}$	0,029	$10,32^{de}$	0,086	$24,52^{f}$	0,180
II	**II**	176	$3,19^{ab}$	0,032	$9,92^{e}$	0,096	$24,26^{f}$	0,201
II	**III**	92	$3,16^{bc}$	0,052	$9,46^{f}$	0,156	$25,19^{cd}$	0,328
III	**I**	88	$3,05^{d}$	0,045	$12,74^{a}$	0,136	$26,27^{a}$	0,286
III	**II**	289	$2,94^{ef}$	0,025	$11,85^{b}$	0,077	$24,93^{e}$	0,161
III	**III**	46	$2,90^{f}$	0,065	$11,40^{b}$	0,195	$25,08^{de}$	0,409
F_{exp}			**		**		**	
Farm x The age of the mother								
I	**I**	96	$2,82^{i}$	0,042	$10,71^{de}$	0,127	$24,28^{fg}$	0,267
I	**II**	92	$3,01^{f}$	0,043	$10,52^{e}$	0,130	$25,04^{e}$	0,274
I	**III**	72	$2,89^{h}$	0,049	$10,29^{ef}$	0,149	$24,16^{fg}$	0,313
I	**IV**	55	$3,15^{d}$	0,059	$11,06^{d}$	0,176	$25,18^{de}$	0,371
I	**V**	44	$3,27^{b}$	0,065	$10,65^{e}$	0,195	$26,50^{a}$	0,409
I	**VI**	111	$3,19^{cd}$	0,045	$10,60^{e}$	0,137	$25,88^{bc}$	0,287
II	**I**	111	$3,34^{a}$	0,041	$10,42^{ef}$	0,124	$24,01^{g}$	0,260
II	**II**	112	$3,18^{d}$	0,039	$10,04^{f}$	0,117	$23,89^{g}$	0,245
II	**III**	64	$3,24^{bc}$	0,055	$9,55^{g}$	0,164	$24,12^{fg}$	0,345
II	**IV**	65	$3,10^{e}$	0,054	$10,04^{f}$	0,163	$24,44^{f}$	0,342
II	**V**	70	$3,13^{de}$	0,052	$10,04^{f}$	0,157	$26,51^{a}$	0,330
II	**VI**	84	$3,13^{de}$	0,051	$9,31^{ag}$	0,153	$24,96^{e}$	0,322
III	**I**	85	$2,99^{fg}$	0,047	$12,43^{a}$	0,140	$25,10^{e}$	0,295
III	**II**	89	$2,95^{f}$	0,046	$12,28^{ab}$	0,139	$25,30^{de}$	0,292
III	**III**	77	$2,98^{fg}$	0,050	$12,23^{ab}$	0,151	$25,59^{cd}$	0,317
III	**IV**	73	$2,95^{g}$	0,054	$11,48^{c}$	0,164	$26,28^{ab}$	0,345
III	**V**	41	$2,96^{g}$	0,068	$11,55^{c}$	0,203	$24,43^{f}$	0,427
III	**VI**	58	$2,95^{g}$	0,059	$11,99^{b}$	0,177	$25,84^{bc}$	0,372
F_{exp}			**		**		**	
Determination coeff. - R^2			$0,273^{**}$		$0,400^{**}$		$0,127^{**}$	

Mean values in columns marked with the same letters do not differ (P>0.05) based on the LSD test
*F-test: N.S. - P > 0.05; * - P < 0.05; ** - P < 0.01; *** - P < 0.001;*

The weight of lambs at birth, as well as their growth until weaning, largely depends on the conditions on the farm itself. These conditions include sheep nutrition, genetic potential, health care, husbandry and farm management. Farms with good grazing, quality sheep nutrition and adequate housing enable the development of healthy and stronger lambs, greater weight at birth and faster growth. Also, regular veterinary care and preventive measures against parasites have a positive effect on the general health of the lambs and their growth. On the other hand, on farms with poor nutrition, poor hygiene and stressful conditions, lambs have a lower initial mass and progress more slowly, which affects the economic profitability of production. Examining the influence

of the farm on the weight of lambs in the lactation period (weight at birth, weight at 30 days and at decision at 90 days of age) it was determined that this systematic factor has a highly significant influence (R 0.01) on the weight of lambs in all three age categories. The weight of lambs at birth is the highest on Farm 2, while the highest weight of lambs at 30 and 90 days of age was recorded on Farm 3. Most authors in their research (Mekić et al., 2008, Tohidi et al., 2017, Petrović D.M. et al., 2022; Jašović et al., 2022; Lečić et al., 2022) state a significant (R>0.05) and very significant (R>0.01) influence of the farm both on the weight at birth and on the growth in the lactation period and therefore on the weight at decision.

The effect of year of birth is primarily reflected through differences in the level of technological and genetic progress, as well as climatic conditions affecting feed production, which is particularly pronounced in countries with less intensive agricultural production, where the majority of livestock feed originates from so-called dry farming systems. Most authors in their studies (Gardner et al., 2007; Milovanović et al., 2015; Stanišić et al., 2016; Radović et al., 2017; Cekić et al., 2021; Petrović D.M. et al., 2022) report a highly significant effect of year of birth on lamb growth traits during the suckling period. In the present study, year of birth had a highly significant effect (P<0.01) only on lamb body weight at 30 days of age. The highest body weight at 30 days (11.28 kg) was recorded in lambs whose dams were born in the period from 2015 to 2017.

According to most authors, the effect of birth order on lamb body weight at birth, at 30 days, and at weaning (90 days) is significant (P<0.05) or highly significant (P<0.01) (Wojtowski et al., 1990; Bathaei and Leroy, 1994; Wilcox et al., 1996; Babar et al., 2004; Petrović et al., 2011; Albieri and Koritiaki, 2013), whereas Petrović D.M. et al. (2022) reported that birth order, i.e., age of the dam, did not have a significant effect (P>0.05) on any of the studied growth traits during the suckling period.

As ewes age and their body weight increases, lamb birth weight also increases, particularly at birth. However, with further aging and increased fat deposition in the abdominal cavity, due to limited space in the uterus, lamb body weight gradually decreases. The highest lamb body weights are generally observed between the third and fifth lambings. In the present study, the effect of this fixed systematic factor on lamb birth weight was not significant (P>0.05), but it had a highly significant effect (P<0.01) on lamb body weight at 30 and 90 days of age.

The effect of type of birth (singletons and twins) on the expression of lamb birth weight and growth during the suckling period is highly significant,

particularly with regard to birth weight, as twins are lighter than single-born lambs. Most authors (Baneh and Hafezian, 2009; Kalantar, 2003; Dixit et al., 2001) report a significant ($P<0.05$) or highly significant effect ($P<0.01$) of type of lambing on birth weight and pre-weaning growth, while only a smaller number of authors (Shahroudi et al., 2003; Matika et al., 2003) report a non-significant effect ($P>0.05$). In the present study, the analysis of this paragenetic factor revealed a highly significant effect ($P<0.01$) on all three observed traits, i.e., single-born lambs were heavier than twins at all measurements.

Sex of lambs also had a highly significant effect ($P<0.01$) on lamb body weight at birth and at 30 and 90 days of age; male lambs had greater body weights than females, as reported by most authors. The body weights of male lambs were 3.18 kg, 11.04 kg, and 25.24 kg, while those of female lambs were 2.95 kg, 10.65 kg, and 24.93 kg at birth, 30 days, and 90 days of age, respectively. The obtained results are consistent with findings reported by numerous authors (Nourian, 2000; Shahroudi et al., 2002; Matika et al., 2003; Gardner et al., 2007; Mekić et al., 2008; Rashidi et al., 2008; Petrović et al., 2015; Tohidi et al., 2017; Cekić et al., 2021; Zeljić et al., 2021).

The interaction between farm and year of birth, as well as between farm and birth order, had a highly significant effect ($P<0.01$) on lamb body weight at birth and at 30 and 90 days of age.

The calculated coefficients of determination (R^2), which indicate the level of variability in lamb body weight at different ages caused by the fixed systematic effects included in the model (farm, year of birth, birth order, type of birth, and sex of lambs), were highly significant ($P<0.01$). The coefficient of determination for lamb birth weight was 0.273 (27.3%), for 30-day body weight 0.400 (40.0%), and for weaning weight at 90 days of age 0.127 (12.7%). The lower values of these coefficients for birth weight and growth during the suckling period indicate that many other factors not included in this study also influenced the expression of these traits.

Conclusion

The study of the influence of various paragenetic factors on lamb body weight during the suckling period (birth weight, weight at 30 and 90 days of age) in the municipality of Gornji Milanovac yielded the following results:

- Farm, type of lambing, sex of lambs, interaction between farm and year of birth, and interaction between farm and birth order had a highly significant effect ($P<0.01$) on lamb body weight at birth, 30 days, and 90 days of age.

- Year of birth had a highly significant effect (P<0.01) only on lamb body weight at 30 days of age.
- Birth order did not significantly affect (P>0.05) lamb body weight at birth, whereas its effect on the other two traits (weight at 30 and 90 days) was highly significant (P<0.01).
- Coefficients of determination were highly significant (P<0.01) and amounted to 0.273 (27.3%) for birth weight, 0.400 (40.0%) for weight at 30 days, and 0.127 (12.7%) for weight at 90 days.

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