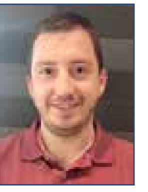
Non-genetic factors affecting litter size, age at first lambing and lambing interval of Romanov sheep in Croatia



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Abstract

Reproductive traits are of paramount importance in an efficient lamb production system. In Croatia, values of reproductive traits of Romanov sheep are below the average expected for this breed, indicating the need for improvement of these traits to exploit the breed's full reproductive potential. This study was conducted on 260 Romanov ewes located at a commercial Romanov sheep farm in Croatia. All ewes were kept under similar conditions, and reproductive management was based on accelerated lambing with continuous mating. Linear models with fixed effects were used to estimate the influence of year of birth/lambing, season of birth/lambing, ram, parity and litter type on litter size (LS), age at first lambing (AFL) and lambing interval (LI). Average LS was 2.11 ± 0.71, while the year of lambing and parity were the most important factors affecting this trait. The smallest litters were recorded after 1st parity (1.77 ± 0.06), and the largest after 5th parity (2.21 ± 0.08). AFL averaged 388.5 ± 72.4 days. All investigated non-genetic factors had a significant (P<0.05) influence on AFL, with year of birth as most important. The average LI was 241.2 ± 70.8 days. A significant (P<0.05) influence of all factors on LI was observed. Ewes lambing in spring (200.2 ± 7.9 days) or summer (190.5 ± 6.6 days) had a significantly (P<0.05) shorter LI than ewes lambing in autumn (227.7 ± 8.3 days) or winter (237.2 ± 6.7 days). The longest LI was observed after the first parity (284.0 ± 5.5 days). Average values for reproductive traits in the examined population of Romanov sheep were higher than those reported in the official Croatian database for breeding sheep. Non-genetic factors have a significant influence on the variation of reproductive traits of Romanov sheep, and therefore should be considered when assessing ewes' reproductive performance.

Key words: *reproductive performance; litter size; age at first lambing; lambing interval; non-genetic factors; Romanov sheep*

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Introduction

Reproductive traits such as age at first service, age at first lambing, lambing frequency and litter size are of paramount importance in an efficient lamb production system (Assan, 2020).

In Croatia, majority of sheep is used for lamb production, and 90% of all sheep belong to the autochthonous breeds which are predominantly bred in the Adriatic part of Croatia (Ministry of Agriculture, 2019; Špoljarić et al., 2021). Among allochthonous breeds in Croatia, Romanov is one of the most numerous, with 47 registered purebred flocks (6.4 % of the total breeding population) (Ministry of Agriculture, 2019). Romanov breed is widely known for its early maturity, aseasonality and prolificacy (Fahmy, 1996). However, official (Ministry of Agriculture, 2019) (litter size = 1.83; lambing index = 1.12 lambings/ewe/year) and scientific (Đuričić et al., 2019, 2021) (litter size = 1.39-1.86) reports on prolificacy and lambing frequency of Romanov ewes imply that the values of these traits are lower than expected for this breed. For example, the average litter size of Romanov sheep was 2.59 in the Czech Republic (Schmidová et al., 2016) and 2.92 in the United States (Murphy et al., 2020). A lambing index of 1.12 means that only 12% of ewes had a lambing interval shorter than one year.

Genetic improvement of reproductive traits can be achieved by within-breed selection, use of major genes and crossbreeding (Notter, 2012; Gootwine, 2020). The Romanov breed is widely used in crossbreeding with less reproductively efficient breeds (María and Ascaso, 1999; Kutluca Korkmaz and Emsen, 2016; Turkyilmaz and Esenbuga, 2019; Freking and Murphy, 2021). However, the relatively low reproductive performance in Romanov sheep in Croatia suggests that the breed is not used to its full potential and that certain within-breed improvement is necessary.

Age at first mating/lambing and lambing interval in Romanov sheep can be improved by implementing more intensive reproductive management, e.g., accelerated lambing. Increasing litter size requires a more systematic approach based on the genetic potential for larger litters and proper nutritional and reproductive management.

Reproductive traits are affected by both genetic and non-genetic factors. Accurate estimation of the magnitude of the effects of these factors is essential for the efficient improvement of reproductive traits. Several authors have examined non-genetic (e.g., year and season of birth, parity, litter type, ram, farm, flock) variations on productive (Murphy et al., 2020; Vlahek et al., 2021) and reproductive traits (Fahmy, 1989; María and Ascaso, 1999; Kutluca Korkmaz and Emsen, 2016; Murphy et al., 2020) of Romanov sheep.

The aim of this study was to assess the reproductive performance of Romanov sheep in a typical, large commercial flock in Croatia, and to estimate the effect of certain non-genetic factors on the reproductive traits of ewes.

Material and methods

Study area, animals and general management

The study was conducted at a commercial Romanov sheep farm in Croatia located at 45° 22′ N latitude and 14° 38′ E longitude. The flock was kept in a semi-intensive production system based on accelerated lambing with continuous mating. The breeding goal was the production of lambs for slaughter with a final bodyweight of about 25 kg, as well as breeding rams and ewe lambs.

Before first mating, ewe lambs aged 5-6 months and rams were joined into breeding groups with 35–40 females and one male. This breeding structure (the same group of ewes and ram) was maintained throughout the observed period. Seven breeding groups were formed by random allocation of selected ewe lambs and rams. Inbreeding was strictly avoided. Once the groups were formed, each ram was kept permanently with the same ewes.

During the day, sheep were kept in large outdoor pens (each breeding group in its own pen). Overnight, sheep were housed indoors in separate pens for each breeding group. Before lambing, ewes were separated into small individual pens. Several days after lambing, ewes and their lambs were joined again with their breeding group. Lambs were weaned at 45 days of age. All sheep were vaccinated and routinely treated against parasites.

Grazing was limited due to the small outdoor pens, so all animals were fed a commercial feed mixture with 16% protein, and meadow hay *ad libitum.*

Recording and the definition of variables

Individual records of 260 Romanov ewes from 2015 to 2020 were used. Year of birth, year of lambing, ram, parity and litter size were determined from the database. Litter size (LS) was recorded immediately after lambing. Age at first lambing (AFL) was calculated as the difference between the date of first lambing and the date of birth of the ewe, while lambing interval (LI) after each parity was calculated as the number of days between two consecutive lambings (e.g., LI after first parity is the number of days from the date of the first lambing to the date of the second lambing). Seasons of birth and lambing were defined as follows: spring (21 March-20 June), summer (21 June-22 September), autumn (23 September-20 December) and winter (21 December-20 March). None of the observed ewes was born in summer.

Variables for the analysis were defined as follows: year of birth (2015–2017), season of birth (spring, autumn, winter), year of lambing (2016-2020), season of lambing (spring–winter), ram (1-7), parity (1-7) and litter type (singleton–quadruplets).

Statistical analysis

Linear regression models with fixed effects were used to estimate the effect of non-genetic factors on the LS, AFL and LI. Analyses were performed using the package “lsmeans” (Lenth, 2016) in the statistical programme R (R Core Team, 2021).

The model used to analyse LS was:

$$Y_{ijkl} = \mu + A_i + S_j + R_k + P_l + e_{ijkl},$$

where Y_{ijkl} = phenotypic value of LS; μ = overall population mean; A_i = fixed effect of the i^{th} year of lambing; S_j = fixed effect of the j^{th} season of lambing; R_k = fixed effect of the k^{th} ram; P_l = fixed effect of the l^{th} parity; e_{ijkl} = residual error.

AFL was analysed with the following model:

$$Y_{ijk} = \mu + A_i + S_j + R_k + e_{ijk},$$

where Y_{ijk} = phenotypic value of AFL; μ = overall population mean; A_i = fixed effect of the i^{th} year of birth; S_j = fixed effect of the j^{th} season of birth; R_k = fixed effect of the k^{th} ram; e_{ijk} = residual error.

The model for LI was:

$$Y_{ijklm} = \mu + A_i + S_j + R_k + P_l + L_m + e_{ijklm},$$

where Y_{ijklm} = phenotypic value of LI; μ = overall population mean; A_i = fixed effect of the i^{th} year of lambing; S_j = fixed effect of the j^{th} season of lambing; R_k = fixed effect of the k^{th} ram; P_l = fixed effect of the l^{th} parity; L_m = fixed effect of the m^{th} litter type; e_{ijklm} = residual error.

ANOVA was used to test for the significant effect of fixed factors, and Tukey post-hoc test for an unequal number of samples was used to test the significance of differences between groups within the same fixed factor. The significance level was set at $P<0.05$.

The relative importance of fixed factors in linear models (% of response variance in litter size, age at first lambing and lambing interval accounted for by explanatory variables) was estimated using "lmg metrics" contained within the "relaimpo" package (Grömping, 2006) of the statistical programme R.

Results and Discussion

In this research, the reproductive performance of Romanov sheep in Croatia was assessed and the influence of non-genetic factors on these traits was estimated.

Descriptive statistics parameters of reproductive traits for the overall population are presented in Table 1. Overall mean ± SD for LS was 2.11 ± 0.71. A larger mean and SD in LS in Romanov sheep were recorded by Murphy et al. (2020; 2.92 ± 1.00), Schmídova et al. (2016; 2.59 ± 0.93) and María and Ascaso (1999; 2.32). Kutluca Korkmaz and Emsen (2016) reported an LS of 2.01. According to the official reports, the LS of Romanov sheep in Croatia (1.83) is lower than recorded in our research. Also, Đuričić et al. (2019, 2021) reported values of LS of Romanov sheep in the continental part of Croatia to be 1.61 and 1.59, respectively. The average LS recorded in this study was expected, given that the breeding scheme was based on accelerated lambing with continuous mating. It is known that ewes exposed to frequent matings may have smaller litters compared to the ewes in the annual lambing system. Ricordeau et al. (1988) recorded an LS of Romanov ewes of 3.11 in the annual lambing system and 2.55 in an accelerated lambing system. The coefficient of variation recorded in our research (33.71%) suggests a relatively large variation in LS. The LS was significantly ($P<0.05$) affected by the season of lambing and parity (Table 2). Variance decomposition indicates the relative importance of season of birth and parity to be 33% and 37%, respectively (Figure 1). The proportion of variation in LS explained by the model was 10.0% ($R^2=0.100$, $F(19, 1231)=7.20$, $P<0.001$). Ewes lambing in spring (2.11 ± 0.07) and winter (2.21 ± 0.05) had larger litters than ewes lambing in summer (1.81 ± 0.06) (Table 3). Similar results regarding LS in different seasons were obtained by María and Ascaso (1999). This indicates that Romanov sheep show a rather low degree of seasonality regarding prolificacy, and only matings occuring during the late winter and spring (considered an anoestrous period in seasonal breeds in the northern hemisphere) resulted in

Table 1. Descriptive statistics for litter size (LS), age at first lambing (AFL) and lambing interval (LI) in Romanov sheep

Reproductive trait	Descriptive statistics parameter					
	n	Mean	SD	Min.	Max.	CV (%)
LS	1251	2.11	0.71	1.00	4.00	33.71
AFL (days)	260	388.5	72.4	290.0	655.0	18.63
LI (days)	991	241.2	70.8	167.0	617.0	29.43

SD – standard deviation; CV – coefficient of variation

Table 2. Variance analysis of litter size (LS), age at first lambing (AFL) and lambing interval (LI) in Romanov sheep

Variable	Fixed factor	Degrees of freedom	Mean square	F-value	*P*-value	R^2 (%)
LS	Year of lambing	4	0.90	1.95	0.100	10.0 (*P*<0.001)
	Season of lambing	3	6.35	13.74	<0.001	
	Ram	6	0.90	1.94	0.072	
	Parity	6	3.00	6.50	<0.001	
AFL	Year of birth	2	38997	10.85	<0.001	34.0 (*P*<0.001)
	Season of birth	2	28632	7.96	<0.001	
	Ram	6	18071	5.03	<0.001	
LI	Year of lambing	4	46054	14.41	<0.001	37.7 (*P*<0.001)
	Season of lambing	3	73338	22.95	<0.001	
	Ram	6	40223	12.59	<0.001	
	Parity	5	112411	35.17	<0.001	
	Litter type	3	22302	6.98	<0.001	

smaller litters. It is well known that LS increases with the advance of age of ewes (order of parity). Murphy et al. (2020) recorded an increase in LS from 2.19 in <1 year old ewes to 2.83 in 3.5-4.5 years old ewes, while LS constantly increased up to 4^{th} parity in Romanov sheep in Spain (María and Ascaso, 1999). Similar trends were observed in Djallonke (Gbangboche et al., 2006), Zandi (Mohammadi et al., 2013), Saint Croix (Sánchez - Dávila et al., 2015), Pelibuey (Tec Canché et al., 2015) and Romanov crossbred (Freking and Murphy, 2021) sheep. This is partly in agreement with the results obtained here, where LS increased up to 5^{th} parity (2.21 ± 0.08) (Table 3). Year of lambing is often included in the models for the LS analyses (Sánchez-Dávila et al., 2015; Tec Canché et al., 2015; Tesema et al., 2020). In the present study, the overall influence of year of lambing on LS was not significant (*P*>0.05) (Table 2), but ewes lambing in 2016 had significantly (*P*<0.05) smaller litters (Table 3), possibly due to the high proportion of first lambings in that year. Ram did not have a significant influence on LS (Table 2). This was expected since all rams were kept under similar conditions (feeding, housing, reproduction management). Sánchez-Dávila et al. (2015) reported significant (*P*<0.05) influence of ram effect on LS in Saint Croix sheep, which was attributed to the fact that rams used were from different farms and of different bloodlines.

The average AFL recorded in our research was 388.5 ± 72.4 days (Table 1). Fahmy (1989) reported the AFL of Romanov ewes to be 372 days, while Kutluca Korkmaz and Emsen (2016) and Đuričić et al. (2019) claimed that the majority of their observed Romanov ewes lambed at one year of age. The coefficient of variation in AFL in this study was 18.63%, which indicates the relative homogeneity of the data. AFL was significantly (*P*<0.05) influenced by all non-genetic factors (Table 2), and relative importance of year of birth, season of birth and ram were

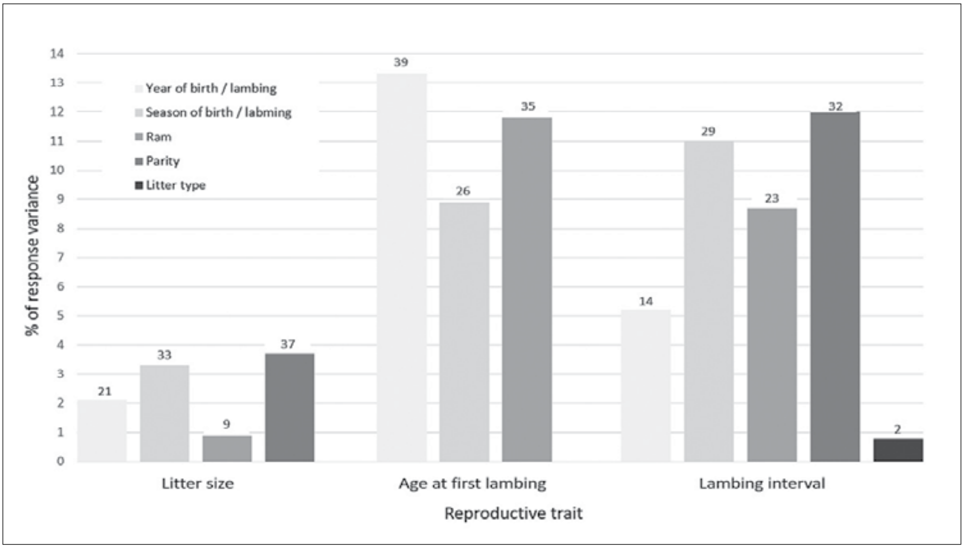

Figure 1. Variance decomposition indicating the percent of variance in litter size, age at first lambing and lambing interval accounted for by explanatory variables

39%, 26% and 35%, respectively (Figure 1). The model explained 34.0% of variation in AFL (R^2=0.340, F (10, 249) = 12.84, *P*<0.001). Ewes born in 2015 lambed at the youngest age (355.1 ± 21.0 days), while those born in 2017 had an estimated AFL of 453.8 ± 44.2 days (Table 3). Significant (*P*<0.05) differences in AFL regarding year of birth have been reported (Gbangboche et al., 2006; Tec Canché et al., 2015), though the magnitude of the differences (up to 46 days) was smaller than those recorded in our research.

Ewes born in 2015 were significantly (*P*<0.05) younger at first lambing than ewes born in 2016 and 2017 (Table 3). Obtained differences in AFL regarding the year of birth can be explained by the season of birth of ewes. Spring and winter born ewes had estimated AFL of 362.9 ± 9.5 and 368.6 ± 8.1 days, respectively, while sheep born in autumn lambed at 493.9 ± 27.6 days. The majority of autumn-born ewes were born in 2017, which resulted in a larger AFL in that year. Differences in AFL regarding season of birth were expected to be smaller, given that all ewes were joined with rams at approximately the same age (5–6 months) and that the Romanov breed is considered to be aseasonal. The results imply that the first mating of ewes born in spring and winter occurred at seven months of age (AFL is around one year), while ewes born in autumn mated for the first time at around one year of age. The majority of first matings in all ewes occurred in autumn. Given that reproductive management of all ewes was similar, it appears that autumn born ewes spent almost six months with the ram, during which time no mating occurred. One possible explanation is that lambs must experience alternate photoperiods (long days preceding short) to begin the reproductive cycle (Foster and Hileman, 2015), so autumn-born ewes did not reach puberty until the following autumn, while winter and spring-born ones reached puberty in the autumn of the year of birth. Ewes mated with ram 6 had significantly (*P*<0.05) lower AFL compared to the ewes kept with rams 1-5 and 7 (Table 3).

Table 3. Least square means ± standard error by factor for litter size (LS), age at first lambing (AFL) and lambing interval (LI) in Romanov sheep

Fixed factor	Level of factor	LS		AFL (days)		LI (days)	
		n	LSM ± SE	*n*	LSM ± SE	*n*	LSM ± SE
Year of birth/ lambing	2015	/	/	69	355.1^{c} ± 21.0	/	/
	2016	130	1.90^{b} ± 0.12	117	416.5^{b} ± 18.9	61	175.4^{c} ± 13.9
	2017	261	2.12^{a} ± 0.08	74	453.8^{a} ± 44.2	187	201.8^{b} ± 8.2
	2018	271	2.02^{b} ± 0.06	/	/	166	212.0^{b} ± 7.5
	2019	404	2.08^{a} ± 0.04	/	/	394	$242.9b^{c}$ ± 4.8
	2020	183	2.06^{a} ± 0.07	/	/	183	267.6^{a} ± 6.5
Season of birth/ lambing	Spring	173	2.11^{a} ± 0.07	95	362.9^{c} ± 9.5	114	200.2^{c} ± 7.9
	Summer	275	1.81^{b} ± 0.06	/	/	272	190.5^{c} ± 6.6
	Autumn	121	2.01^{ab} ± 0.08	42	493.9^{a} ± 27.6	115	227.7^{b} ± 8.3
	Winter	682	2.21^{a} ± 0.05	123	368.6^{b} ± 8.1	490	237.2^{a} ± 6.7
Ram code	1	205	2.12 ± 0.05	33	452.5^{ac} ± 26.2	172	235.3^{bc} ± 5.3
	2	249	1.98 ± 0.05	40	448.0^{ac} ± 25.6	209	219.0^{cd} ± 5.1
	3	227	2.11 ± 0.05	38	439.5^{ac} ± 25.5	189	219.7^{bcd} ± 5.2
	4	188	1.96 ± 0.06	38	402.5^{a} ± 23.0	150	208.9^{d} ± 6.8
	5	99	2.00 ± 0.10	35	410.2^{a} ± 42.9	64	241.2^{a} ± 11.3
	6	152	2.11 ± 0.08	38	363.1^{b} ± 30.4	114	178.8^{bc} ± 8.9
	7	131	1.97 ± 0.09	38	343.2^{c} ± 43.7	93	194.6^{b} ± 9.9
Parity	1	260	1.77^{b} ± 0.06	/	/	263	284.0^{a} ± 5.5
	2	263	2.09^{ac} ± 0.05	/	/	246	228.3^{b} ± 5.2
	3	246	2.05^{bc} ± 0.05	/	/	194	198.4^{b} ± 6.3
	4	194	2.17^{a} ± 0.06	/	/	140	209.6^{b} ± 7.7
	5	140	2.21^{ac} ± 0.08	/	/	97	169.0^{b} ± 9.6
	6	97	2.08^{ac} ± 0.10	/	/	51	194.2^{b} ± 11.8
	7	51	1.88^{bc} ± 0.13	/	/	/	/
Litter type	Singleton	/	/	/	/	167	199.9 ± 6.2
	Twins	/	/	/	/	585	203.4 ± 5.0
	Triplets	/	/	/	/	216	221.2 ± 5.6
	Quadruplets	/	/	/	/	23	231.1 ± 12.7

^{a,b,c,d} – Least square means within factor with different superscript letters differ significantly ($P<0.05$)

The average LI of 276 ± 9.5 days recorded by Fahmy (1989) in Romanov sheep was 35 days longer than the average LI recorded in our research, while absolute (SD=9.5 days) and relative (CV=3.40%) variability of LI was much smaller compared to our findings (SD=70.8 days; CV=29.43%) (Table 1). The large variation in LI seen in this study could have been caused by mating management (continuous mating), while Romanov ewes in the study by Fahmy (1989) were mated three times in two years, with separation of rams after each mating period. All investigated factors significantly (P<0.05) influenced LI (Table 2), with parity being the one with the largest relative importance (32%) (Figure 1). The proportion of variation in LI explained by the model was 37.7% (R^2=0.377, F(21, 969) = 27.90, P<0.001). The longest LI was recorded after the first parity (284.0 ± 5.5 days) which was significantly (P<0.05) longer than LI after the 2^{nd} – 7^{th} parities (Table 3). This is in agreement with the findings of María and Ascaso (1999) in Romanov sheep, and Komprej et al. (2011) in the Jezersko-Solčava breed and Improved Jezersko-Solčava breed. However, Fahmy (1989) reported a small and non-significant (P>0.05) effect of parity on LI in Romanov sheep. In our research, ewes lambing in autumn (227.7 ± 8.3 days) and winter (237.2 ± 6.7 days) had significantly (P<0.05) longer LI than spring (200.2 ± 7.9 days) and summer (190.5 ± 6.6 days) lambing ewes (Table 3). On the contrary, María and Ascaso (1999) recorded significantly (P<0.05) longer LI in ewes lambing in spring and summer. Year of lambing had a significant (P<0.05) effect on LI (Table 2), which is in agreement with the findings of Gbangboche et al. (2006), while Tec Canché et al. (2015) found that LI did not change significantly (P>0.05) throughout years. Estimated LI varied between 178.8 ± 8.9 days in ewes kept with ram 6, and 241.2 ± 11.3 days in ewes kept with ram 5 (Table 3). LI increased with the increase of birth type and ranged from 199.9 ± 6.2 days in ewes with singletons to 231.1 ± 12.7 days in ewes with quadruplets, but differences were not significant (P>0.05) (Table 3). Significant (P<0.05) differences in LI regarding litter type were recorded in Romanov (María and Ascaso, 1999), Djallonke, (Gbangboche et al., 2006), Jezersko-Solčava (Komprej et al., 2011) and Pelibuey (Tec Canché et al., 2015) breeds. Vanimisetti and Notter (2012) reported non-significant (P>0.05) differences in the first and second lambing intervals of Polypay ewes with different litter types. María and Ascaso (1999) discussed that one of the possible reasons for the longer LI in ewes with larger litters might be higher milk production in multiparous ewes. Ricordeau et al. (1990) reported milk production of 1.7-1.8 kg and 2.3-2.5 kg in Romanov ewes lambing twins and triplets, respectively. High milk production can cause energy deficiency in multiparous ewes, which then affects and delays reproductive activity.

Conclusion

The average values for reproductive traits in an observed population of Romanov sheep were higher than values reported in the official Croatian database for breeding sheep. Non-genetic factors had significant effects on the variation of reproductive performance of ewes included in this study. Specifically, the season of lambing and parity had the greatest influence on litter size and lambing interval, while the most important factor for age at first lambing was the year of birth. These factors should be considered in the evaluation of Romanov sheep reproductive performance and in the development of breeding strategies to raise reproductive efficiency.

References

1. ASSAN, N. (2020): Indicators of reproductive performance in goats and sheep meat production. Sci. J. Anim. Sci. 9, 608-619.
2. ĐURIČIĆ, D., M. BENIĆ, I. ŽURA ŽAJA, H. VALPOTIĆ and M. SAMARDŽIJA (2019): Influence of season, rainfall and air temperature on the reproductive efficiency in Romanov sheep in Croatia. Int. J. Biometeorol. 63, 817-824. 10.1007/s00484-019-01696-z
3. ĐURIČIĆ, D., A. DOBOS, J. GRBAVAC, C. STILES, I. BACAN, Ž. VIDAS, F. MARKOVIĆ, P. KOČILA and M. SAMARDŽIJA (2021): Climate impacts on reproductive performance of Romanov sheep in the moderate climate. J. Anim. Behav. Biometeorol. 10, 2201. 10.31893/jabb.22001
4. FAHMY, M. H. (1989): Reproductive performance, growth and wool production of Romanov sheep in Canada. Small Rumin. Res. 2, 252-264. 10.1016/0921-4488(89)90005-9
5. FAHMY, M. (1996): Prolific sheep. Cab International, Wallingtonford, UK, 9-108.
6. FOSTER, D. L. and S. M. HILEMAN (2015): Puberty in the sheep. In: Knobil and Neill's physiology of reproduction: volume two, (Plant, T. M. and A. J. Zeleznik, eds.), Elsevier, USA, pp. 1441-1485. 10.1016/B978-0-12-397175-3.00031-4
7. FREKING, B. A. and T. W. MURPHY (2021): Comparison of performance of F1 Romanov crossbred ewes with wool and hair breeds during spring lambing under intensive and extensive production systems. J. Anim. Sci. 99, 1-10. 10.1093/jas/skaa397
8. GBANGBOCHE, A. B., M. ADAMOU - NDIAEYE, A. K. I. YOUSSAO, F. FARNIR, J. DETILLEUX, F. A. ABIOLA and P. L. LEROY (2006): Non-genetic factors affecting the reproduction performance, lamb growth and productivity indices of Djallonke sheep. Small Rumin. Res. 64, 133-142. 10.1016/j.smallrumres.2005.04.006
9. GOOTWINE, E. (2020): Invited Review: Opportunities for genetic improvement toward higher prolificacy in sheep. Small Rumin. Res. 186, 1-13. 10.1016/j.smallrumres.2020.106090
10. GRÖMPING, U. (2006): Relative importance for linear regression in R: the package relaimpo. J. Stat. Softw. 17, 1-27. 10.18637/jss.v017.i01
11. KOMPREJ, A., G. GORJANC and D. KOMPAN (2011): Lambing interval in Jezersko-solčava and Improved jezersko-Solčava breed. Agric. Conspec. Sci. 76, 353-356.
12. KUTLUCA KORKMAZ, M. and E. EMSEN (2016): Growth and reproductive traits of purebred and crossbred Romanov lambs in Eastern Anatolia. Anim. Reprod. 13, 3-6. 10.21451/1984-3143-AR722
13. LENTH, R. V. (2016): Least-squares means: the R package lsmeans. J. Stat. Softw. 69, 1-33. 10.18637/jss.v069.i01
14. MARÍA, G. A. and M. S. ASCASO (1999): Litter size, lambing interval and lamb mortality of Salz, Rasa Aragonesa, Romanov and F1 ewes on accelerated lambing management. Small Rumin. Res. 32, 167-172. 10.1016/S0921-4488(98)00176-X
15. MINISTRY OF AGRICULTURE (2019): Sheep, goat and small animals breeding. In: Annual report for sheep, goats and small animals breeding in Republic of Croatia for 2018, Ministry of Agriculture, Vinkovci, Croatia.
16. MOHAMMADI, K., M. T. BEIGI NASSIRI, E. RAHMATNEJAD, M. SHEIKH, J. FAYAZI and A. K. MANESH (2013): Phenotypic and genetic parameter estimates for reproductive traits in Zandi sheep. Trop. Anim. Health Prod. 45, 671-677. 10.1007/s11250-012-0276-0
17. MURPHY, T. W., J. W. KEELE and B. A. FREKING (2020): Genetic and nongenetic factors influencing ewe prolificacy and lamb body weight in a closed Romanov flock. J. Anim. Sci. 98, 1-8. 10.1093/jas/skaa283
18. NOTTER, D. R. (2012): Genetic improvement of reproductive efficiency of sheep and goats. Anim. Reprod. Sci. 130, 147-151. 10.1016/j.anireprosci.2012.01.008
19. R CORE TEAM (2021): A language and environment for statistical computing, Vienna, Austria, https://www.R-project.org/.
20. RICORDEAU, G., L. TCHAMITCHIAN and J. P. POIVEY (1988): Performance, development and use of Romanov in France. J. Agric. Sci. Finl. 60, 558-565. 10.23986/afsci.72313
21. RICORDEAU, G., J. THIMONIER, J. P. POIVEY, M. A. DRIANCOURT, M. T. HOCHEREAU-DE-REVIERS and L. TCHAMITCHIAN (1990): I.N.R.A. research on the Romanov sheep breed in France: a review. Livest. Prod. Sci. 24, 305-332. 10.1016/0301-6226(90)90009-U
22. SÁNCHEZ-DÁVILA, F., H. BERNAL-BARRAGÁN, G. PADILLA-RIVAS, A. S. DEL BOSQUE-GONZÁLES, J. VÁZQUEZ-ARMIJO and R. A. LEDEZMA-TORRES (2015): Environmental factors and ram influence litter size, birth, and weaning weight in Saint Croix hair sheep under semi-arid conditions in Mexico. Trop. Anim. Health Prod. 47, 825-831. 10.1007/s11250-015-0795-6
23. SCHMIDOVÁ, J., M. MILERSKI, A. SVITÁKOVA, L. VOSTRÝ and A. NOVOTNÁ (2016): Estimation of genetic parameters for litter size in Charollais, Romney, Merinolandschaf, Romanov, Suffolk, Šumava and Texel breeds of sheep. Small Rumin. Res. 119, 33-38. 10.1016/j.smallrumres.2014.02.004
24. ŠPOLJARIĆ, D., G. KIŠ, K. VLAHOVIĆ, I. MUJEZINOVIĆ, A. HRKOVIĆ POROBIJA, L. PAJURIN, T. MALONE, S. VINCE, V. ŠEGOTA, M. M. KARDUM PARO, B. ŠPOLJARIĆ and M. POPOVIĆ (2021): The effect of the botanical composition of pastures on the immune status of the Lika Pramenka sheep breed. Vet. stn. 52, 45-55. (in Croatian). 10.46419/vs.52.1.4

25. TEC CANCHÉ, J. E., J. G. MAGANA MONFORTE and J. C. SEGURA CORREA (2015): Environmental effects on productive and reproductive performance of Pelibuey ewes in Southeastern Mexico. J. Appl. Anim. Res. 44, 508-512.10.1080/09712119.2015.1102730
26. TESEMA, Z., B. DERIBE, A. KEFALE, M. LAKEW, M. TILAHUN, M. SHIBESH, N. BELAYNEH, A. ZEGEYE, G. WORKU and L. YIZENGAW (2020): Survival analysis and reproductive performance of Dorper x Tumele sheep. Heliyon 6, e03840. 10.1016/j.heliyon.2020.e03840
27. TURKYILMAZ, D. and N. ESENBUGA (2019): Increasing the productivity of Morkaraman sheep through crossbreeding with prolific Romanov sheep under semi-intensive production systems. S. Afr. J. Anim. Sci. 49, 185-191. 10.4314/sajas.v49i1.21
28. VANIMISETTI, H. B. and D. R. NOTTER (2012): Opportunities for genetic evaluation of reproductive performance in accelerated lambing systems. Livest. Sci. 148, 134-145. 10.1016/j.livsci.2012.05.022
29. VLAHEK, I., A. EKERT KABALIN, S. MENČIK, M. MAURIĆ MALJKOVIĆ, A. PIPLICA, H. KABALIN, J. ŠAVORIĆ and V. SUŠIĆ (2021): The effect of non-genetic factors on the birth weight of Romanov sheep. Vet. arhiv 91, 615-624. 10.24099/vet.arhiv.1487

Utjecaj paragenetskih čimbenika na veličinu legla, dob pri prvom janjenju i međujanjidbeno razdoblje ovaca romanovske pasmine u Hrvatskoj

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