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VARIABILITY OF MORPHOLOGICAL AND GROWTH CHARACTERISTICS OF THE WURTTEMBERG SHEEP BREED

VARIJABILNOST MORFOLOŠKIH I OSOBINA PORASTA VIRTEMBERG RASE OVACA

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ABSTRACT

The aim of this study was to determine and present the basic characteristics of Wurttemberg sheep, which includes analyzes of the characteristics of body measurements of sheep, with detailed statistical analysis, in order to define the degree of variability of characteristics, as well as to investigate environmental influences (sex, year birth, season and type of birth) on the examined traits using general linear method and estimating genetic parameters for lamb growth traits, using BreedR software package in R statistical programming environment. The research was conducted on a sample of 964 sheep, 860 females and 104 males. The following morphological characteristics were examined: Height to withers, body length, girth of chest, depth of chest, witdh of chest, width of pelvic and circumference of the testicles of rams. From the physiological traits, i.e. production traits, the following were examined: body weight at birth, body weight at 30 days and body weight at 90 days of age, i.e. weight at weaning, weight in the first year and weight at 3 years. The results of the research showed that the characteristics of the body measurements of sheep and rams, are similar or equal to the characteristics that are standard for the breed, while in sheep the height to withers and the girth of chest were at lower values than the standard. Body weight values in the first as well as at the age of three were at the level of breed standards, while the weight of lambs at birth was lower than the standard. Sex and year of birth had a statistically highly significant (** = P <0.001) influence on all examined morphological traits, while in addition to these factors, body lenght was influenced by the type of birth and width of chest by birth season. The year and type of birth had a statistically highly significant (** = P <0.001) influence on the growth characteristics of lambs, while the sex and year of birth had influence on body weight in the first year as well as at the age of 3 years. Heritability was at the level of medium values, for the trait of body weight at birth 0.30, for body weight at 30 days 0.23, the highest for body weight at weaning 0.38.

Keywords: Wurttemberg sheep, body measurements, growth traits, environmental factors, heritability.

SAŽETAK

Cilj ove studije bio je da se utvrde i predstave osnovne karakteristike virtemberške ovce, pri čemu su u istraživanje uključene analize osobina telesnih mera ovaca, uz detaljnu statističku analizu, u cilju definisanja stepena varijabilnosti osobina, kao i da se istraže uticaji okoline (pol, godina rođenja, sezona i tip rođenja) na ispitivane osobine primenom opšte linearne metode i procenom genetskih parametara za osobine porasta jagnjadi, korišćenjem softverskog paketa BreedR u okruženju za statističko programiranje R. Istraživanje je sprovedeno na uzorku od 964 grla, 860 ženki i 104 mužjaka. Ispitivane su sledeće morfološke karakteristike: visina grebena, dužina tela, obim grudnog koša, dubina grudnog koša, širina grudnog koša, širina karlice i obim testisa ovnova. Od fizioloških, odnosno proizvodnih osobina, ispitivane su: telesna masa pri rođenju, telesna masa sa 30 dana i telesna masa u dobi od 90 dana, odnosno težina pri odbijanju, težina u prvoj godini

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i težina sa 3 godine. Rezultati istraživanja su pokazali da su karakteristike telesnih mera ovaca i ovnova slične ili jednake karakteristikama koje su standardne za rasu, dok su kod ovaca visina grebena i obim grudnog koša bili na nižim vrednostima od standardne. Vrednosti telesne mase u prvoj kao i u uzrastu od tri godine bile su na nivou standarda rase, dok je težina jagnjadi pri rođenju bila niža od standarda. Pol i godina rođenja imali su statistički visoko značajan (** = P <0.001) uticaj na sve ispitivane morfološke osobine, dok su pored ovih faktora na dužinu tela uticali tip rođenja i sezona na širinu grudnog koša. Godina i tip rođenja imali su statistički visoko značajan (** = P <0.001) uticaj na osobine porasta jagnjadi, dok su pol i godina rođenja imali uticaj na telesnu masu u prvoj godini, kao i u uzrastu od 3 godine. Heritabilnost je bila na nivou srednjih vrednosti, za osobinu telesne mase pri rođenju 0.30, za telesnu masu sa 30 dana 0.23, najviša za telesnu masu pri odbijanju 0.38.

Ključne reči: Virtemberg ovca, telesne mere, proizvodne osobine, faktori okoline, heritabilnost.

1. INTRODUCTION

The Wurttemberg sheep (Merino Landschaf) is a typical breed for meat and wool production that is widespread, and in the area of the Balkan it is used for crossing with Pramenka sheep in order to increase fattening characteristics and meat yield. A serious undertaking to improve the production of lamb meat was made by introducing the Wurttemberg sheep into sheep breeding programs in Serbia (1). Many scientific studies have confirmed the opinion that this breed is used only in the programs of industrial crossbreeding of some local populations in order to increase the growth of lambs. Due to the existence of meat breeds, with more pronounced fattening characteristics, and above all higher quality of lamb carcasses and better physical, chemical and sensory properties of meat, breeding Wurttemberg sheep in pure breed is not of interest (2, 3, 4, 5, 6, 7).

According to the data of the selection service, and recent research, the body weight of adult sheep ranges from 70-75 kg, and rams 100-120 kg, the height to withers in sheep averages about 70 cm, and rams 80 cm, the body weight of lambs at birth is about 4.5 kg. In conditions of intensive fattening, lambs reach a body weight of 25-30 kg at the age of 90 days. The meat yield ranges from 52-56%. The yield of wool per sheep is 4-4.5 kg, and in rams 5-6 kg. The wool yield is about 50%. Milk production is weak or moderate, although milk is mainly used for raising offspring. It starts with mating at 10 (female) or 12 months of age (male). Out of 100 sheep, an average of 120-140 lambs are obtained. Due to the excellent body structure, good production, good health and very good acclimatization ability, this breed has been exported, and even today it is exported to many countries around the world. This breed was especially important for the improvement of sheep production in our country because, above all, it participated in the creation of Pirot's breed sheep. In addition, in recent years she has been the main ameliorator of many other strains of Pramenka in our country, with very good results (8). In the coming period, Serbian sheep breeding should work on improving the genetic potential of sheep, and this can be achieved by crossing domestic breeds with rams of the Wurttemberg breed, creating new genotypes for meat production and creating new genotypes for combined production (7).

Linear body measurements on live animals are widespread and are used in research work as a simple tool for recording certain aspects of animal growth and shape (9, 10). Linear measurements can be used to assess growth rate, weight, food utilization, and carcass characteristics, to monitor the relationship between production performance, visual assessment, and physical measurements (11, 12). The production characteristics of sheep depend on a number of genetic and non-genetic factors, in order to successfully organize sheep production we must have a breeding program, and know which factors affect production (13). Among them are year and season, which is primarily reflected through nutrition, housing and care of animals during the production cycle, especially during pregnancy (14).

In order for the selection to be successfully carried out for the purpose of obtaining higher sheep meat production, it is necessary to know the external factors on which the quantity and quality of meat depend (accommodation, nutrition, care), as well as genetic parameters (heritability, repitability, genetic

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correlations) that have an economic effect on production (15). With known high values of heritability coefficients, it is possible, based on phenotypic expressiveness, to predict the genetic value of an individual, which is considered important in selection programs (16).

There is a relatively small number of such studies in this breed, so the main goal of this study is to look at some of the indicators of variability of morphological and physiological characteristics of sheep, comparing the animals of different farms, but also comparing the variability of examined traits, phenotypes, under the influence of different factors and examine the heritability coefficient for lamb growth traits.

2. MATERIALS AND METHODS

The data used in this research were collected over a period of 8 years, taken from the database of the basic breeding organization "Association of Farmers" Batocina, which includes sheep raised in the Sumadija district. Based on the examined 964 sheep, there were 860 females and 104 males. Data entered into the sheep registry program, which is constructed in the form of a relational database, were extracted and classified using SQL (Structured Query Language) codes, and then the elimination of incorrectly entered, extreme values of individual parameters was performed using program codes in R statistical software environment, in which were calculated the basic parameters of descriptive statistical analysis, environmental impact on the examined traits using a general linear model, as well as further processing using the method of best linear indicators BLUP to assess the genetic value of animals.

Examination of phenotypic expression and variability of traits was performed by calculating the basic parameters of descriptive statistical analysis such as: arithmetic mean, standard error of arithmetic mean, standard deviation (SD), coefficient of variation (CV (%)), interval of variation (min - max).

From the morphological traits the following were examined: Height to Withers (HW), Body Length (BL), Girth of Chest (GC), Depth of Chest (DC), Witdh of Chest (WC), Width of Pelvic (WP) and circumference of the testicles of rams (CT).

From the physiological traits, i.e. production traits, the following were examined: body weight at birth (BW0), body weight at 30 days (BW30) and body weight at 90 days (BW90=WW) of age, i.e. weight at weaning (weaning weight), weight in the first year (BW1) and weight at 3 years (BW3).

Statistical analysis of the influence of a number of non-genetic factors on the manifestation of morphological and production characteristics of growth was examined. The analysis of the influence of non-genetic environmental factors was performed using a general linear model. The application of this procedure enables the simultaneous analysis of several different influences, regardless of whether they are categorical or continuous factors by their nature. For estimating the effects and testing hypotheses, the general linear model is based on the application of least squares methods. Data were also processed in a free licensed programming environment (17), using the program Least-Squares Means.

By analyzing the influence of non-genetic environmental factors using a general linear model, the influences of the following factors were examined: Influence of sex, influence of year of birth, birth season and influence of birth type.

The following model was used to analyze the influence of individual non-genetic factors on body measurements traits:

$$y_{ijkmn} = \mu + G_r + P_l + R_s + T_r + e_{ijklmn},$$

in which:

y_{ijkmn} - individual of the i-th farm, j-th group of the year of birth, k-th sex, m-th season of birth, fixed influence of the n-th type of birth.

μ - general average of the population with equal representation of all classes of influence (Oi + GLj + STk + Srl + Grm + GrSrml),

Gr - fixed influence of the j-th year of birth,

Pl - fixed influence of the k-th sex,

Rs - fixed influence of the m-th season of birth,

Tr - fixed influence of the n-th type of birth and

e_{ijklmn} - other indeterminate influences.

The calculation of genetic parameters was performed using the software package BreedR (18), in the R statistical software environment, which uses the program BLUPF90 (19) using the REML (average information restricted maximum likelihood) method. An animal model was used to

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define additive genetic and environmental variance. The software solutions used in the research are open source, i.e. free.

Heritability (h^2) was singled out for traits: body weight at birth (BW0), body weight at 30 days (BW30) and body weight at 90 days (BW90=WW) of age, i.e. weight at weaning (weaning weight).

3. RESULTS AND DISCUSSION

3.1. DESCRIPTIVE STATISTICS FOR BODY MEASUREMENTS TRAITS

The following tables show the results of examining the characteristics of the body measurements of the Wurttemberg breed, which were bred in the Sumadija district. Based on the collected data, the basic parameters of descriptive statistics for these traits were determined, and the influence of a number of non-genetic factors on the manifestation of these traits was presented using a general linear model. Table 1. shows the results of descriptive statistics for the morphological characteristics of sheep and rams, while the table 2. shows the results of descriptive statistics for the physiological characteristics.

Table 1. Morphological characteristics of sheep and rams

	Sex	HW	WC	BL	DC	WP/CT	GC
n	male	104	104	104	104	104	104
	female	860	860	860	860	860	860
$\overline{X}$	male	80.3	37	84.1	39.4	31.8	123
	female	66.2	31.7	73.5	35.9	27	91.8
$S_{\overline{x}}$	male	0.20	0.23	0.399	0.27	0.596	1.250
	female	0.11	0.07	0.132	0.05	0.039	0.147
SD	male	2.05	2.33	4.07	2.74	6.08	12.8
	female	3.17	1.95	3.88	1.41	1.14	4.31
min	male	75	33	74	34	23	93
	female	56	24	57	30	20	80
max	male	87	44	95	46	41	150
	female	79	37	91	40	30	123

The average height to withers in rams was 80.3 cm, which is approximately the same value of the HW as pointed out by many authors, 80 cm on average (1, 20), as well as in accordance with the Institute of Animal Husbandry (8). Chest width averaged 37 cm, body length averaged 84.1 cm, in the range of 74-95 cm. The average chest depth of rams was 39.4 cm, ranging from 34-46 cm. Testicular circumference was 31.8 cm, 23 cm minimum and 41 cm maximum. The average chest girth of rams was 123 cm, in the range of 93-150 cm.

The average height to withers in sheep was 66.2 cm, which is a lower value compared to the HW pointed out by many authors, 70 cm on average (1, 20, 21). In the results of the research obtained by Petrović et al. (21), body lenght in sheep is smaller, on average 72.11 cm, pelvic width is also smaller, on average 25.82 cm, while in our results the body length is 73.5 cm, pelvic width 27 cm, while chest girth is larger, on average 97.66 cm, in our results it is 91.88 cm.

Table 2. Physiological characteristics of sheep and rams

	Sex	BW0	BW30	BW90	BW1	BW3
n	male	104	104	104	104	104
	female	860	860	860	860	860
$\overline{X}$	male	3.71	15.4	27.6	85.8	94.1
	female	3.59	14.7	27	62.5	67.7
$S_{\overline{x}}$	male	0.068	0.137	0.249	0.653	0.793
	female	0.018	0.047	0.084	0.142	0.118
SD	male	0.692	1.39	2.54	6.66	8.09
	female	0.516	1.39	2.48	4.17	3.45
min	male	2.6	12	23	70	83
	female	2.3	10	22	52	57
max	male	5.5	19	34	120	132
	female	5.6	26	38	92	98

The average birth weight was 3.71 kg in male lambs and 3.59 kg in females, Petrović (1)

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found a higher value for this trait, which was 4.95 kg. Also, Skalicki and Ristevski (22) found a higher value for the body weight of lambs at birth in the Wurttemberg breed imported to Macedonia, where the value was 4.05 kg. According to Krogmeier (23), the body weight of Wurttemberg lambs at birth in Germany is 4.90 kg. The body weight of male lambs on weaning was on average 27.6 kg, and female 27 kg, which is approximately with the research of Petrovic (1) who states that lambs reach a weight of 25-30 kg on average with 90 days.

Mekic et al. (20) stated that the body weight of one-year-old animals is 50-55 kg in females and 90-110 kg in males, 110-130 kg in adult rams, and 60-75 kg in sheep. In our research, the body weight in the first year in males averaged 85.8 kg, in the range of 70-120 kg, in females 62.5 kg, ranged from 52-92 kg. Body weight at 3 years in rams averaged 94.1 kg, in intervals of 83-132 kg, in sheep an average of 67.7 kg, from a minimum of 57 kg to a maximum of 98 kg, which is within the breed standard.

3.2. ANALYSIS OF THE INFLUENCE OF ENVIRONMENTAL FACTORS ON EXAMINED TRAITS

Tables 3 and 4 show the analysis of the influence of environmental factors on examined traits, in table 3 on morphological and in table 4 on physiological traits.

Table 3. Results of the linear model of analysis of morphological characteristics.

Traits	Factors			
	Sex	Year of birth	Birth season	Birth type
HW	< .001	< .001	0.019	0.180
BL	< .001	< .001	0.021	< .001
DC	< .001	< .001	0.020	0.005
WC	< .001	< .001	< .001	0.100
GC	< .001	< .001	0.119	0.649
WP/CT	< .001	< .001	0.174	0.923

ns=P>0,005; *=P<0,005; **=P<0,001;

The analysis of the results of the morphological traits of sheep and rams, using a general linear model, found a statistically highly significant (** p <0.001) influence of sex and year of birth on all traits, while in addition to these factors, body lenght was influenced by birth type, and width of chest by birth season. It was determined that the effect of sex was significant for all traits of body measurements, where males had higher values for all traits compared to females. Similar results in their research are confirmed by Petrović et al. (21) also in the Wurttemberg breed, Jafari and Hashemi (24) in the Makui, Lalit et al. (25) in Harnali breed and Dauda et al. (26) in Balami breed. Dauda et al. (26) stated that the superiority of males over females in some physical traits may be the result of the secretion of the hormone testosterone secreted by males. As in these studies, so did Kumar et al. (27), as well as Das et al. (28) in their research stated that the type of birth and the season of birth had an impact on certain characteristics of body measurements, while on most did not.

Table 4. Results of the linear model of analysis of physiological characteristics.

Traits	Factors			
	Sex	Year of birth	Birth season	Birth type
BW0	0.037	< .001	0.776	< .001
BW30	0.008	< .001	0.014	< .001
BW90	0.002	< .001	0.010	< .001
BW1	< .001	< .001	0.044	0.151
BW3	< .001	< .001	0.840	0.642

ns=P>0,005; *=P<0,005; **=P<0,001;

According to the results of the analysis of the general linear model, a statistically highly significant (**p<0.001) influence of year and type of birth on BW0, BW30 and BW90 was determined. Many authors (14, 29, 30) conclude that the year and type of birth have an impact on the characteristics of the body mass of lambs growing and at birth, while in the research of Zeljić et al. (31) in Bergamo lambs, Boujenane and Dialla (32) in Sardi lambs, year and type of birth had an impact on body weight at birth, while on body weight at 30 days and on weaning did not. Body weight at birth and weaning depends on many environmental factors. Among them are the year and the season, which is primarily reflected in the nutrition, housing

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and care of animals during the production cycle, especially during pregnancy (14).

Sex and year of birth had the statistically highly significant (**p<0.001) influence on body weight in the first year, as well as at the age of 3. As it is generally known that the increase in males is higher, so it has been proven in this study, and the same is confirmed by many authors (30, 33, 34, 35, 36). The year of birth had an impact on these traits, which has also been confirmed in many studies (34, 37, 38, 39), and Rahimi et al. (39) in their study of Makui sheep stated that this could be due to differences in farm management, food availability, disease, and climate (rainfall, humidity, and temperature) that affect pasture quality and quantity in different years.

3.3. HERITABILITY COEFFICIENT FOR LAMB GROWTH TRAITS

The results of the assessment of genetic parameters for growth characteristics of lambs, i.e. the heritability coefficient for these characteristics, are shown in table 5.

Table 5. Values of heritability (h^2) and standard errors of heritability (S_h^2) for growth characteristics of lambs.

Traits	h^2	S_h^2
BW0	0.3022	0.0973
BW30	0.2392	0.1032
BW90	0.3828	0.1086

low heritability = < 0.2; medium heritability = 0.2-0.5; high heritability = >0.5

Heritability was at the level of medium values, for the trait of body weight at birth 0.3022, for body weight at 30 days 0.2392, highest for body weight at weaning 0.3828. The value of heritability for body weight at birth is higher in our research compared to many, where it ranged from 0.03 (40) in the Romney Marsh lambs to 0.46 (41) in the Menz lambs. For body weight at 30 days and at weaning is more or less in relation to many studies, where it has been proven that the coefficient of heritability for these traits in lambs ranges from low to medium values (15, 36, 40, 41, 42, 43, 44, 45, 46).

If we compare our research with the research of Zeljić et al. (15) in Sjenicka Pramenka, the coefficient of heritability is at significantly higher values for body weight at birth, where it was 0.03, lower for body weight at 30 days, 0.46 in their results, and higher for body weight at weaning in relation to their results where it was 0.30. Determined coefficient values and standard error of heritability differ considerably between some authors what can be a consequence of research conducted in different populations, breeds, types of sheep (different size and structure of samples), different conditions of keeping as well as various applied models for calculating heritability. In addition, migration, selection and inbreeding can change the value of this coefficient (15).

4. CONCLUSIONS

Based on the given results for sheep and rams of the Wurttemberg breed examined in this study, most of the examined parameters were found to meet breed standards, while some traits show a lower value compared to the breed standards and traits researched and ascertained by domestic authors for this breed of sheep. Results of this study showed that certain non-genetic factors have a significant influence on the morphological and growth characteristics of the Wurttemberg sheep breed. Sex and year of birth had a statistically highly significant influence on all morphological traits, while in addition to these factors, body lenght was influenced by the type of birth and width of chest by birth season. The year and type of birth had the highest influence on the growth characteristics of lambs, while on the body weight in the first and in the third year, a year of birth and sex. The coefficient of heritability was at the level of medium values, for body weight at birth much higher in our research compared to many, while for body weight at 30 days and at weaning more or less in relation to many studies. All examined characteristics are influenced by diet, care, manner of keeping and selection, which means that we must constantly work on improving all these conditions as well as on more correct selection. This breed is constantly being tested with the aim of obtaining the highest quality breeding material, so it is necessary to do more such research, in order to contribute to improving the selection of this breed.

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