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BIOTECHNOLOGY IN ANIMAL HUSBANDRY

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THE PHENOMENON OF HETEROSIS AND EXPERIENCE IN CROSSING DIFFERENT BREEDS OF SHEEP IN SERBIA

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Review paper

Abstract: Crossbreeding serves as a predictable and cost-effective method to genetically increase lamb body weight by mating two or more breeds of sheep. The crossing over breed comes to a far greater number of combinations of genes and thus is more likely to express favorable allele carriers of economically important traits. The phenomenon of heterosis has used since the beginning of the last century. However, its genetic basis has remained unclear. From the very beginning of the knowledge of heterosis to the present day, there are several theories, but neither theory able to answer all questions that arise regarding the apparent strength of the F1 generation offspring. Not assert anything about the genetic or molecular phenomenon that causes heterosis. It has been increasingly experimentally confirmed that heterosis is the result of highly complex interactions within the genome as well as between the genome and the environment. In Serbia, some activity of domestic researchers regarding crossbreeding of sheep after the Second World War has been recorded up to date. It found out that crosses have a higher body weight than the maternal base in the F1 generation. In other words, they had better fattening capacity than purebreds. However, the results are not always in line with expectations due to the influence of various known and unknown factors.This review paper aims to draw attention to the phenomenon of heterosis through experience in its application in Serbia, in the hope that this biological phenomenon would clarify in the near future by applying modern scientific understandings and technologies.

Keywords: heterosis, crossbreeding, sheep, lamb, body weight

Introduction

Breed diversity is a treasured resource of the sheep industry, and the crossbreeding systems use breed diversity to increase productivity relative to purebred flocks *(Dawson and Carson, 2002; Leymaster, 2002).* The crossbreeding schemes aiming at the utilization of general and specific combining ability and breed substitution are some of the available methods that can be used to improve the productivity of the local breeds of sheep (*Mavrogenis, 1995*; *Gavojdian et al., 2013; Petrovic, 2013; Wolfová et al., 2014).* Purebreds are the raw material of crossbreeding, and good crossbreds only come from good purebreds particularly, the higher the genetic merit or breeding value of the purebreds, the higher the expected performance of the crossbreds *(Mitchell, 2000; Dvalishvili et al., 2015).* To improve the performance of low heritability, crossbreeding is often used, and when only one trait has considered, a heterosis effect seems minor. On the other hand, heterosis effects accumulate to provide rather a substantial improvement over straight bred sheep when the total productivity of such as lamb survivability and the growth rate has considered. Since no any breed best for all traits, the second benefit of crossbreeding is the advantageous use of breed complementary which refers to the combination of desirable traits from one or more breeds into one animal wherein the idea is that the strengths of one breed will compensate for the weaknesses of another breed *(Aaron, 2014).* Selecting the right population in the application of crossing and crossing system is necessary to fulfill its goal in sheep breeding (*Caro Petrovic et al., 2015).* Crossbreeding serves as a predictable and cost-effective method to genetically increase lambs rose per ewe (lamb crop) and by mating two or more breeds of sheep. Important genetic considerations to increase lamb crop were to use breeds and crossbreds that are suitable for the production system and well adapted to environmental conditions *(Leymaster, 2016).* Crossing over breed comes to a far greater number of combinations of genes and thus is more likely to express favorable allele carriers of economically important traits *(Petrovic et al., 2013).* The breeds of sheep had evolved over many thousands of years, their utility and function guided by their ability to adapt and survive in specific environments and production systems *(Leymaster, 2002).* An organized crossbreeding system can optimize the use of both hybrid vigor and breed complementarity and can have utilized by flocks of all sizes *(Thomas, 2006).* Making the most of crossbreeding is a combination of enhancing hybrid vigor and also selecting breeds that provide traits that maximized production within the farming system *(Mitchell, 2000).* This paper aims to draw attention to the phenomenon of heterosis through experience in its application in Serbia, in the hope that this biological phenomenon will be clarified in the near future by the application of modern scientific understandings and technologies.

The phenomenon of heterosis

In the broadest sense, heterosis indicates the appearance of a better expression of some quantitative traits (fertility, growth, food conversion, etc.) of F1 generation offspring relative to parents (*Petrovic et al., 1997).* The phenomenon of heterosis has used since the beginning of the last century in livestock and crop production, however, its genetic basis has remained unclear. From the very beginning of the knowledge of heterosis to the present day, there are several theories, which associate this phenomenon with gene dominance, superdominant and epistasis. None of the several theories is capable of answering all the questions that arise regarding the apparent strength of the F1 generation offspring. Writing about the fundamental aspects of sheep crossbreeding, *Leymaster (2002*) points out that complementarity, or the complementarity with each other, of the positive traits of crossbreeding breeds, is responsible for heterosis. However, this does not assert anything about the genetic or molecular phenomenon that causes heterosis. It has been increasingly experimentally confirmed that heterosis is the result of highly complex interactions within the genome as well as between the genome and the environment. However, no one has yet succeeded in explaining these intricate biological processes. In support of the scientific quest for an answer, we dare to state our position on it. We believe that the biological processes that take place inside the organism at the cell and gene level are quite superficially understood and simplified. Cells, as the basic but extremely complex and perfect unit of life, structure, function, and expression of genes, are still being treated mechanically-the principle of the key and lock, despite key technological advances. One allele pair of a gene or a particular group of genes is considered to carry fixed information, which must be expressed with minor deviations in plus or minus depending on the external environment, according to the formula P = G + E. The livestock environment generally includes climatic factors, nutrition, and animal care. The results of scientific studies show that there are high variations in the degree of expression of heterosis, despite the fulfillment of some conditions that are considered crucial for success in crossbreeding. In the study of *Colak et al. (2013*), the crossing of Akkaraman sheep with Hasak and Hasmer types did not improve the fattening performance and carcass quality compared with purebred Akkaraman lambs. The following table presents the usual schematic representation of gene interactions at crosses. Practice shows that the effects of crossbreeding are not completely consistent with this "alphabetic-mechanical" model.

Table 1.Example of the occurrence of heterosis depending on gene interaction (*Petrovic, 2000).*

Generation	Dominance	Over dominance	Epistasis
P	ААбб	А1А1Б1Б1	ААББ
	ааББ	А2А2Б2Б2	Аабб
F1	АаБб	А1А2Б1Б2	АаБб

As is well known the quantum physics is a thorough scientific discipline found in the description of matter, and energy, and is the basis of many disciplines, such as physics and chemistry, which means that it is the basis of everything. Therefore, it is logical to expect that its principles will be in biochemistry as well as molecular biology leading to the gene itself. That then we should not be surprised that life comes from quantum mechanics. Biology has pretty well explained many life processes at the molecule level. However, as stated in the paper of *Arndt et al. (2009*), quantum physics and electrodynamics shape all molecules and thus, separate molecular recognition, protein work and DNA. Thus, van der Valsal's forces, discrete molecular orbitals, and maternal stability are all quantum physics and the natural basis of life and everything that is visible. Quantum aspects of life are increasingly being studied by a number of scholars around the world, presenting interesting results and ideas such as *Blankenship R E (2002*), *Eisert and Viseman (2007),Gariaev et al. (2011)* and others. Because we thought that the phenomenon of heterosis could explained by a complete understanding of the principles of quantum physics, which gave birth to quantum biology, which will play a very important role in the future.

Prerequisite for the crossing program

Every sheep breeding program has to accept two basic factors if it is to succeed: genetic distance between crossed populations and crossing system.
It has argued that if the genetic distance or difference between populations selected for crossbreeding is greater, the effect of heterosis, and thus meat production will be greater. For example, if we cross two local breeds with low production, we will not certainly achieve a significant improvement in desirable traits in the offspring. There have been cases where no progress has made in the crossing of meaty breeds of similar production levels (*Petrovic, 2000*). Genetic differences between breeds are examined during the cross-breeding of sheep to realize breeding plans as efficiently as possible (*Konig et al., 2016*). A better knowledge of both the superiority and inferiority of exotic breed to the local breed will help design a more effective and reliable crossbreeding program *(Li et al., 2016)*. Another important factor that depends on the success of the crossing is the crossing system. It also has an impact on results (*Petrovic et al., 2011*). The results showed that in the system

of crossing two breeds of sheep only the heterosis of individual has used, while at the three-breed crossing beside the heterosis of individual, the heterosis of the mother has added, and in crossing of four breeds, in addition to the mentioned, the heterosis of the father has used.

Experience in crossing different breeds of sheep in Serbia

Sheep breeding as a method for increasing meat production in our country has not yet found wider practical application. However, in the domain of experimental scientific work, some activity of domestic researchers after the Second World War has been recorded to date *(Mitic et al., 1964; 1974; Kostic et al., 1977; Mitić, 1982; Petrovic, 2000; Petrovic et al., 2011; Caro Petrovic, 2014).* As the maternal have used female Pramenka breed of sheep, Tsigai, Merino and their two breed crosses, and rams of meaty sheep breeds. Thus, during the sixth and seventh decade of the twentieth century were found that crosses have a higher body weight than the maternal base in the F1 generation. In other words, they had better fattening capacity than purebreds (table 2). However, the results are not always in line with expectations due to the influence of various known and unknown factors.

Table 2. Effects of crossbreeding of different breeds of sheep in Serbia during the sixth and seventh decades of the last century *(Mitic,1984)*

Genotype and crossing combination	Lambs body weight, kg		Age at weaning, days	Average daily gain, g
	At birth	Weaning		
Svirlig x Precose	3.57	24.75	100	206
Svirlig x Precose x Caucasian	3.75	25.15	100	208
Svirlig x Precose x Wirtemberg	4.23	25.45	100	212
Svirlig x Precose x Southdown	3.70	27.67	100	239
German Blackhead x Tsigai	4.85	28.00	100	232
German Blackhead x Tsigai x Southdown	4.80	28.50	100	237
Pirot x Merino d'Arl	3.88	21.71	90	198
Pirotska x Merino d'Arl x Wirtemberg	3.91	23.20	90	214
Svirlig x Corriedale	3.80	23.50	120	167
Svirlig x Corriedale x Caucasian	3.74	24.30	120	187
Caucasian x Stavropol	4.47	24.23	100	208
Caucasian x Stavropol x Southdown	4.42	28.44	100	240

According to *Mitic (1984*), to use heterosis in meat production, crosses of Tsigai with Ile de france and Hampshire rams were performed in F1 generation had higher body weight in both cases than purebred Tsigai sheep. In addition to the above activities on the use of heterosis, a group of researchers during that time, led by the mentioned author, crossed a Tsigai breed with a German black-headed sheep, a Tsigai with a Merino sheep, as well as some Russian sheep breeds. The offspring

from these crosses reached a body weight of up to 27.40 kg in the second case and 27.46 kg in the third case, while lambs of pure Tsigai breed had a weight of 26.56 kg. Positive results in the use of heterosis in our country have also obtained when crossing the Tsigai breed with Suffolk and Tsigai with Ile de France (*Petrovic, 2000*). We see that the terminal paternal breed Southdown has a positive effect, but not the same in all combinations of crossbreeding.

Table 3. Average body weight of lambs by genotype and age *(Petrović, 2000)*

Genotype	Body weight of lambs. kg	
	At birth	At 100 days
Stavroplol x Caucasian	4.47 ± 0.08	25.23 ± 0.58
Stavroplol x Caucasian x Southdown	4.42 ± 0.08	28.44 ± 0.71
Tsigai x German blackhead	4.85 ± 0.13	28.00 ± 0.66
Tsigai x German blackhead x Southdown	4.80 ± 0.15	28.50 ± 0.63
Svrlig x Prekoce	3.57 ± 0.15	24.75 ± 0.69
Svrlig x Prekoce x Southdown	3.70 ± 0.08	27.67 ± 0.74

A significant step in terms of increasing meat production in our country was made by introducing Weremberg sheep into breeding programs for domestic sheep populations. It was evident on the increase in lamb growth (*Petrovic and Nenadic, 1992*), as presented from the following table.

Table 4. Effect of Pramenka strain crossbreeding with the Wirtemberg (W) breed of sheep

Genotype	Body weight of lambs, kg		Daily gain, g
	At birth	With 90 days	
Svrlig (SV)	3.66	16.94	147
Sjenica (SJ)	3.81	19.68	176
R_1(SV xW)	3.92	21.07	190
R_1(SJ x W)	3.98	22.17	202

Under production conditions, crossing the Pramenka strain with the Wertemberg sheep resulted in an increase in body weight and daily gain. However, differences in weight and weight of lambs are evident.

Based on the positive results of crossbreeding, for further genetic improvement of Serbian sheep production, considerable research had conducted since the early 1990s with the aim of finding new possibilities for increasing lamb production (*Petrovic and Negovanovic, 1994; Petrovic et al., 1995*).

In this sense, as states *Petrovic (2000),* started the process of crossing the two-breed crosses with the third terminal breed, and remarkable results have been obtained (Table 5).
The table showed that in addition to a significant heterosis effect of two-bred crossing, three-bred crossing resulted in higher growth and body weight, which is, among the other thing, conditioned by the complete use (100%) of both the heterosis of the individual and heterosis of the mother.

Table 5. Effect of two- and three-fold crossbreeding on the expression of heterosis *(Petrovic et al., 1995; Petrovic, 2006)*

Genotype		Body weight of lambs, kg		Daily gain, g
		At birth	With 90 days	
A	Pure breed	3.85	20.52	185
A x B	Two breed	4.18	25.64	239
A x C	Two breed	3.80	26.76	255
D x C	Two breed	4.85	26.92	243
A x B x C	Three breed	4.45	31.86	303

Based on our past experience in breeding our domestic sheep population, with the aim of increasing meat production, we can conclude that, in addition to the Wirtemberg, the Il de France breed stands out in importance (*Petrovic, 2006*). These breeds have well adapted to our breeding conditions (*Mekić, 1994*). The results displayed in the next table.

Table 6. Body weight averages at birth (BWB), ages 30 days (BW30), 60 days (BW60) and 90 days (BW90) of different genotypes (*Caro Petrovic et al.,2015*).

Genotype/ crossing system	BWB		BW30		BW60		BW90	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
P	3.65	0.03	9.48	0.11	14.99	0.13	21.96	0.24
W	4.48	0.08	10.83	0.17	19.11	0.27	27.70	0.15
PxW	4.17	0.04	10.98	0.11	18.53	0.21	26.55	0.21
PxWxF	4.35	0.04	12.87	0.10	22.01	0.25	32.19	0.20

Conclusion

Heterosis is a biological phenomenon, which today attracts the same attention of the scientific public as at the beginning of the development of genetics. Many of the principles of its manifestation have clarified, but the substance is still

shrouded in secrecy. Not a lot has gone down in its shedding even using molecular genetics methods, but one thing is for sure. Heterosis has found practical application in many countries, where it makes a significant contribution to increasing the production of lamb meat, which is actually the real purpose of its implementation. Regardless of some research aimed at using the heterosis effect in our country from the Second World War to the present, the following can be stated. There are big differences depending on genotype and crossbreed combination. Most experiments were pioneering, sporadic, with no clearly defined objective, and on a small number of experimental individuals. In most cases, have not been analyzed the fixed effects of genetic and external factors. No unique method has used, and therefore, no possible comparison of results. Therefore, to date, in Serbia, we do not have a thorough, clear picture of which genotypes and crossing systems are most suitable for our practical and commercial conditions. Starting from the natural potentials, traditions, and interests of our producers, crossbreeding should be given priority in future programs for the production of quality lamb for domestic and foreign markets. In doing so, research on the various aspects of the occurrence of the heterosis effect should be continued, with particular reference to the elucidation of its phenomenon at the molecular and quantum levels.

Fenomen heterozisa i iskustvo u ukrštanju različitih rasa ovaca u Srbiji

Milan P. Petrovic, Violeta Caro Petrovic, Dragana Ruzic Muslic, Nevena Maksimovic, Ivan Pavlovic, Bogdan Cekic, Ivan Cosic

Rezime

Ukrštanje služi kao predvidljiva i isplativa metoda za genetsko povećavanje mase tela janjadi i drugih osobina, kombinovanim parenjem dve ili više rasa ovaca. Ovim postupkom se teoretski dolazi do daleko većeg broja kombinacija gena i na taj način je verovatnije da će se desitii povoljnije alelne veze nosioci ekonomski važnih osobina. Fenomen heterozisa se izučava i ukrštanjem praktično koristi od početka prošlog veka. Međutim, njegova genetska osnova je ostala nejasna. Od samog početka saznanja o heterozisu pa do danas, postoji nekoliko teorija, ali nijedna nije u stanju da odgovori na sva pitanja koja se javljaju u vezi sa očiglednom snagom potomstva generacije F1. Nema ozbiljnijih saznanja o molekularnom fenomenu koji uzrokuje heterozis. Sve više je eksperimentalno potvrđeno da je heterozis rezultat veoma složenih interakcija unutar genoma, kao i između genoma i okoline. U Srbiji je do danas zabeležena određena aktivnost domaćih istraživača u vezi sa ukrštanjem ovaca posle drugog svetskog rata. Došlo se do saznanja da melezi imaju veću telesnu masu od majčine rase u F1generaciji.

Drugim rečima, imali su bolje performanse tova od čistokrvnih populacija. Međutim, rezultati nisu uvek u skladu sa očekivanjima usled uticaja raznih poznatih i nepoznatih faktora. Takođe svetsko iskustvo u primeni heterozisa pokazuje da postoji i negativan efekat ili nezadovoljavajući u odnosu na očekivani bez obzira na ispunjenost uslova u smislu današnjeg shvatanja heterozisa. Ovaj pregledni rad ima za cilj da skrene pažnju na fenomen heterozisa iskustvom primene u Srbiji, u nadi da će se ovaj biološki fenomen razjasniti u bliskoj budućnosti primenom savremenijih naučnih tehnologija i shvatanja funkcije i uloge gena.

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ANALYSIS OF PRODUCTION TRAITS AND MICROCLIMATE PARAMETERS ON DAIRY CATTLE FARMS

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Abstract: Aiming determination of the variability of production traits (daily milk yield and composition) and microclimate parameters (ambient temperature and humidity) in the barns; as well as the correlation between the analyzed groups of traits, 1,636,192 test-day records from Simmentals and 1,275,713 test-day records from Holsteins were analysed. Performed analysis indicate high variability of production traits due to cow's breed, parity as well as breeding region. Also, high variability of microclimate parameters in the barns due to season and breeding region was found. Furthermore, statistically highly significant ($p < 0.001$) correlations between the production traits and microclimate parameters were determined. Finally, the negative effect of inadequate microclimate on daily milk production was determined in both breeds in all breeding regions. Since genetic evaluation and selection of dairy cattle for heat resistance is only long-term method for heat stress managing, determined effect will be taken into account in the statistical model for estimation of genetic parameters and breeding values.

Key words: production traits, dairy cows, microclimate parameters

Introduction

As climate change has become a pervasive topic in global agricultural production, thus, heat stress in Europe is becoming a growing problem in livestock production especially in dairy cattle breeding *(Gauly et al., 2013)*. Every day we are witnessing faster and more pronounced climate change around the world. These changes will result in increasingly unfavourable climatic conditions for agricultural and especially livestock production *(IPCC, 2007).* For instance, *Reiczigel et al. (2009)* in Hungary, as well as *Dunn et al. (2014)* in UK indicated an increase of heat stress days per year. *Almeida et al. (2011)* stated that the optimal ambient

temperature for dairy production depends on the species, breed, feed intake, age, acclimatization, yield levels, coat and hair characteristics and also on animal tolerance to heat and cold. Also, accordingly to *Santos Daltro et al. (2017),* high-producing dairy cows are more sensitive to heat stress because, by increasing milk production, cows produce more metabolic heat. In accordance to *Vasconcelos and Demetrio (2011),* selection for milk production reduces the ability of the cow to withstand the stress caused by heat and consequently during the hotter months of the year, increases susceptibility to heat stress and decreases production and reproductive efficiency. Similarly, *Hansen (2013)* stated that the high production makes cows more susceptible to heat stress meaning that heat stress will become, and already is, a problem in intensive dairy breeding systems regardless the climate changes. *Bohmanova (2006)* and *Collier et al. (2006)* determined that production level significantly alter the animal response to heat stress making high production animals more sensitive to heat stress than low production ones. Heat stress adversely affects the milk production and its composition in dairy animals, especially animals of high genetic value *(Bouraoui et al., 2002; West, 2003; Spiers et al., 2004; Upadhyay et al., 2009; Wheelock et al., 2010; Gantner et al. 2011, 2017).* Besides, in heat stressed dairy animals, maintenance requirements of energy also increased by 30% *(NRC, 2007).* Furthermore, heat stress also effects health of dairy animals by imposing direct or indirect affects in normal physiology, metabolism, hormonal and immunity system *(Das et al., 2016). Balfoussia et al. (2014)* determined that the acclimatization to long-term stress results in proteomic changes indicated by expression of proteins related to inflammation, while *Min et al. (2016)* concluded that long-term moderate heat stress may lead to an inflammatory response in dairy cows with significantly increased plasma TNF-α and IL-6, which presents a pro-inflammatory factors. Finally, heat stress induces considerable profit loss *(St-Pierre et al., 2003).* Heat stress is considered to be a combination of temperature and humidity that exceed the comfort zone of a cow. The most common measure of heat stress in dairy cattle is temperature-humidity index (THI) that includes ambient temperature and relative humidity *(Kibler, 1964).* The THI threshold value at which heat stress affects milk production and feed intake vary, depending on study, from 68 to 72 *(Du Preez et al., 1990a, b; Bouraoui et al., 2002; Bernabucci et al., 2010; Gantner et al., 2011; Collier end Hall, 2012),* while *Vitali et al. (2009)* emphasised the increased risk of animals' death at THI = 80. There are numerous methods to reduce the effect of heat stress on dairy cows, that is short-term and long-term methods. Short-term methods include optimization of feeding and application of different cooling systems in farm buildings, while long-term methods mean selection of dairy cattle for resistance to heat stress. Taking into account the unquestionability of climate change, the necessity of adequate adaptation strategies in order to decrease negative effects of climate change on domestic animals was pointed out by *Segnalini et al. (2013).* As preconditions for genetic evaluation and selection of

dairy cattle for heat resistance the goals of this study were: 1. Determination of phenotypic variability of the analyzed groups of traits: a. statistical analysis of production traits (daily milk yield and composition) of dairy cows under selection, b. statistical analysis of microclimate parameters (ambient temperature and humidity) in the barns; and 2. Determination of the correlation between the analyzed groups of traits.

Material and Methods

For the analysis of the variability of production traits and microclimate parameters, test-day records of Holstein and dairy Simmental cows reared in Croatia were used. Test-day records were collected during the regular milk recording performed monthly in accordance to the alternative milk recording method (AT4 / BT4) in the period from January 2005 to December 2013. At each recording, measuring and sampling of milk were performed during the evening or morning milkings. Also, at each recording, ambient temperature and relative humidity in the barns were recorded. Based on measured microclimate parameters, temperature-humidity index (THI) was calculated using the following equation by *Kibler (1964)*:

$$THI = 1.8 \times Ta - (1 - RH) \times (Ta - 14.3) + 32$$

Where Ta presents the average temperature in degrees Celsius while RH is the relative humidity as a fraction of the unit. Furthermore, test-day records with lactation stage in (< 5 days and > 500 days), age at first calving in (< 21 and > 36 months), missing parity, missing breed, missing or nonsense daily milk traits (accordingly to ICAR standards, 2017), and missing or nonsense Ta and RH value were deleted from the dataset. After logical control dataset consisted of 1,636,192 test-day records from 117,659 Simmentals (10,599 farms) and 1,275,713 test-day records from 90,159 Holsteins (6,701 farms). Accordingly, to the parity, cows were divided into four classes: I., II., III., and IV. (animals in fourth and higher lactations). Furthermore, accordingly to location of farm, test day records were divided into three breeding regions: Eastern, Central, and Mediterranean. While, in accordance to the recording date, test day records were divided into four recording season: spring, summer, autumn, and winter.

For the logical control of data, determination of the variability of the analyzed groups of traits (production traits and microclimate parameters); and determination of the correlation between the analyzed groups of traits SAS/STAT (*SAS Institute Inc., 2000*) was used.

Results

The variability of production traits of dairy cows that is daily milk yield, daily fat, protein, lactose and urea content as well as somatic cell count accordingly to breed and parity, separately for each region (Eastern, Central, and Mediterranean) is presented in the Tables 1, 2, and 3.

Table 1. Variability (mean; SD) of daily production traits accordingly to breed and parity in Eastern region

Trait / Parity	Holstein				Simmental			
	I.	II.	III.	IV.	I.	II.	III.	IV.
DMY	21.50±7.8	24.23±10.4	24.57±10.7	23.45±10.5	15.42±5.1	16.60±6.1	17.20±6.4	16.61±6.2
DFC	4.09±0.9	4.13±1.0	4.13±1.0	4.11±1.0	4.12±0.9	4.12±0.9	4.10±0.9	4.06±0.9
DPC	3.41±0.4	3.44±0.5	4.00±0.5	3.36±0.45	3.45±0.5	3.49±0.5	3.47±0.5	3.43±0.5
DLC	4.53±0.2	4.44±0.2	4.41±0.2	4.36±0.26	4.57±0.2	4.50±0.2	4.46±0.2	4.42±0.3
DUC	23.24±9.0	23.95±9.2	23.49±9.3	22.67±9.6	21.34±11.6	21.54±11.7	21.70±11.7	21.28±11.6
SCC	16.42±1.9	16.77±2.1	17.07±2.1	17.34±2.2	16.12±2.0	16.44±2.1	16.64±2.1	17.03±2.2

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); DUC – daily urea content (mg/ml); SCC – log transformed somatic cell count

In Eastern region, the highest average daily milk yield (DMY) was determined in Holstein breed in third parity, while the lowest DMY was in Simmental breed in first parity. Daily fat content (DFC) was the lowest at the fourth parity in Simmental breed while the daily protein content (DPC) and daily lactose content (DLC) were the lowest in Holstein breed at the fourth parity. Daily urea content (DUC) was the highest at the second parity in Holstein breed. Finally, highest somatic cell count was determined in fourth parity in both breeds, with higher value determined in Holsteins.

Table 2. Variability (mean; SD) of daily production traits accordingly to breed and parity in Central region

Trait / Parity	Holstein				Simmental			
	I.	II.	III.	IV.	I.	II.	III.	IV.
DMY	18.31±6.4	19.55±7.8	19.91±8.0	19.00±7.7	14.86±5.3	15.74±6.2	16.05±6.3	15.17±5.9
DFC	4.26±0.9	4.31±0.9	4.28±0.9	4.20±0.9	4.27±0.8	4.22±0.9	4.22±0.9	4.11±0.9
DPC	3.40±0.5	3.46±0.5	3.41±0.5	3.36±0.5	3.45±0.5	3.51±0.5	3.47±0.5	3.43±0.5
DLC	4.53±0.2	4.45±0.2	4.41±0.2	4.37±0.2	4.57±0.2	4.50±0.2	4.47±0.2	4.43±0.2
DUC	21.13±10.4	20.85±10.4	20.18±10.4	19.43±10.3	19.77±10.2	19.69±10.4	19.45±10.3	18.86±10.2
SCC	16.59±2.1	16.99±2.1	17.23±2.2	17.62±2.2	16.08±2.0	16.41±2.1	16.65±2.1	17.03±2.2

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); DUC – daily urea content (mg/ml); SCC – log transformed somatic cell count

In dairy cattle reared in Central region, the lowest value of daily milk yield (DMY) was determined in Simmental breed at first parity, while the highest daily milk production was in Holstein breed at third parity. Daily fat content (DFC) was the highest in Holstein breed at the second parity while daily protein content (DPC) and daily lactose content (DLC) were the lowest at the fourth parity in Holstein breed. Daily urea content (DUC) was the lowest at the fourth parity in Simmental breed, while the highest was at first parity in Holstein breed. Similarly like in cows reared in Eastern region, the highest somatic cell count was determined in cows of both breed in fourth lactation.

Table 3. Variability (mean; SD) of daily production traits accordingly to breed and parity in Mediterranean region

Trait / Parity	Holstein				Simmental			
	I.	II.	III.	IV.	I.	II.	III.	IV.
DMY	21.71±7.7	23.44±9.9	24.20±10.5	22.61±10.7	13.51±5.0	14.19±5.9	14.43±6.1	14.20±5.3
DFC	3.84±0.8	3.88±0.9	3.86±0.9	3.81±0.9	4.17±0.9	4.13±0.9	4.16±1.0	4.12±1.0
DPC	3.35±0.4	3.38±0.4	3.34±0.4	3.26±0.4	3.48±0.4	3.49±0.5	3.43±0.5	3.43±0.4
DLC	4.53±0.2	4.43±0.2	4.40±0.2	4.33±0.3	4.54±0.2	4.48±0.2	4.45±0.2	4.41±0.2
DUC	22.38±8.8	23.24±9.2	23.27±9.4	22.69±9.6	21.04±10.0	22.25±10.6	21.21±10.3	20.66±9.9
SCC	16.05±1.9	16.47±2.1	16.90±2.2	17.32±2.3	15.96±2.0	16.32±2.2	16.67±2.2	17.06±2.3

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); DUC – daily urea content (mg/ml); SCC – log transformed somatic cell count

Similarly like in other regions, in Mediterranean region, the highest daily milk production was determined in cows in third parity in both breeds, with higher production in Holsteins. The highest daily fat content (DFC) was observed in first parity Simmentals while the highest value of daily protein content was determined in Simmentals in second parity. Similarly like in other regions, daily urea content was higher in Holsteins comparing to Simmental breed. Also, slightly higher values of somatic cell count were determined in Holsteins.

The variability of microclimate parameters that is ambient temperature, relative humidity and temperature-humidity index (THI)) in the barns accordingly to breed, season and breeding region is presented in the Table 4.

The maximum ambient temperature (T) as well as the highest temperature-humidity index (THI) were recorded in the summer season in the Mediterranean region in the barns where Holstein cows were reared, while the minimum temperature was recorded in the winter season, also in Holsteins' barns but in other region – Eastern. Furthermore, the highest value of relative humidity (RH) was determined in Central region, in Simmentals' barns during the winter season.

Table 4. Variability (mean; SD) of microclimate parameters accordingly to breed, recording season and breeding region

Parameter / Season	Holstein				Simmental			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
	Eastern region							
T	13.42±5.7	23.73±5.8	14.23±6.3	5.72±5.4	12.96±6.1	22.30±5.9	14.12±6.2	6.25±5.0
RH	66.44±12.8	64.18±13.3	67.06±13.9	69.58±14.7	67.90±11.1	67.28±11.4	70.05±10.8	71.31±11.3
THI	56.39±8.4	71.20±8.2	57.38±9.3	44.76±8.4	55.63±9.0	69.37±8.5	57.32±9.3	45.51±7.6
	Central region							
T	15.69±5.8	23.90±5.0	16.20±5.7	9.31±4.5	15.91±5.7	24.05±5.1	16.58±5.6	9.88±4.4
RH	68.12±10.7	69.08±10.9	71.62±10.3	72.84±9.9	69.18±10.3	69.87±10.5	72.52±9.8	73.86±9.5
THI	59.70±8.5	72.00±7.5	60.57±8.6	50.09±7.0	60.03±8.5	72.30±7.6	61.15±8.5	50.91±6.9
	Mediterranean region							
T	14.73±5.0	25.17±4.9	15.70±5.2	9.12±5.1	16.46±4.4	22.43±4.8	16.81±4.5	12.20±3.9
RH	68.75±9.5	70.58±11.1	70.06±8.9	70.73±10.0	70.18±10.6	69.37±11.5	72.26±9.7	71.43±9.9
THI	58.42±5.6	73.99±7.2	59.91±7.9	49.95±7.7	60.97±6.7	69.78±7.0	61.48±6.9	54.59±6.0

* T – ambient temperature (°C); RH – relative humidity; THI – temperature humidity index

Table 5. Correlations between the production traits and microclimate parameters accordingly to breed and breeding region

trait	Holstein						Simmental					
	DMY	DFC	DPC	DLC	DUC	SCC	DMY	DFC	DPC	DLC	DUC	SCC
	Eastern region											
T	-0.032	-0.105	-0.134	-0.019	0.197	0.013	-0.011	-0.123	-0.124	0.0126	0.204	-0.021
RH	0.044	0.040	0.013	-0.017	0.017	-0.222	-0.014	0.010	0.016	-0.024	-0.042	0.034
THI	-0.033	-0.106	-0.133	-0.016	0.195	0.013	-0.011	-0.134	-0.125	0.014	0.205	-0.022
	Central region											
T	-0.012	-0.127	-0.116	-0.016	0.225	-0.004	0.0034	-0.133	-0.129	0.018	0.226	-0.025
RH	-0.039	0.039	0.038	-0.017	-0.013	0.020	-0.019	0.022	0.026	-0.025	-0.032	0.021
THI	-0.012	-0.136	-0.115	-0.016	0.223	-0.004	0.003	-0.133	-0.128	0.018	0.225	-0.025
	Mediterranean region											
T	-0.094	-0.051	-0.073	0.005	0.116	0.003	0.0066	-0.085	-0.112	0.005	0.170	-0.014
RH	-0.065	-0.016	-0.018	0.002	-0.083	0.009	-0.017	-0.001	0.057	0.020	0.101	-0.008
THI	-0.094	-0.053	-0.072	0.007	0.112	0.001	0.066	-0.084	-0.106	0.007	0.177	-0.015

* DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); DLC – daily lactose content (%); DUC – daily urea content (mg/ml); SCC – log transformed somatic cell count; T – ambient temperature (^{o}C); RH – relative humidity; THI – temperature humidity index; all correlation coefficients were statistically highly significant ($p<0.001$)

The correlations between the production traits of dairy cows (daily milk yield, daily fat, protein lactose and urea content and somatic cell count) and the microclimate parameters (ambient temperature, relative humidity and temperature-humidity index – THI) in the barns accordingly to the breed and breeding region are presented in the Table 5. All determined correlation coefficients were statistically highly significant ($p < 0.001$). A negative effect of increased ambient temperature on daily milk yield (DMY) and daily fat, protein and lactose content (DFC, DPC and DLC) was determined in both breeds in all analysed regions. The most pronounced negative effect of increased ambient temperature of DMY in Holsteins was determined in Mediterranean region, while in Simmental breed the highest drop in daily milk production was observed in Central region. The negative effect of high relative humidity in the barns was observed in Holsteins reared in Central and Mediterranean region, as well as in Simmentals reared in Central region. The increase of temperature-humidity index resulted in decrease of daily milk yield, and high variability in daily compositions in both breeds in all analysed regions.

Discussion

Performed analysis indicate high variability of production traits due to cow's breed, parity as well as breeding region. Also, high variability of microclimate parameters in the barns due to season and breeding region was found. Furthermore, statistically highly significant ($p<0.001$) correlations between the production traits and microclimate parameters were determined. Finally, the negative effect of inadequate microclimate on daily milk production was determined in both breeds in all breeding regions.

Accordingly, to *Kadzere et al. (2002)* the intensive genetic selection for high milk production resulted in changes in the thermoregulation physiology of dairy cattle. Larger frames and larger gastrointestinal tracts in high production animals enable them to digest more feed, but also creates more metabolic heat and reduces the animal's ability to regulate temperature heat stress environment meaning that increased milk yield, feed intake and metabolic heat the thermo-neutrality to lower temperatures. Furthermore, highly productive dairy cattle lose their ability to regulate body temperature at an air temperature of only 25 to 29°C. For example, *Berman (2005)* notified that increasing of daily production from 35 to 45 kg results in a higher sensitivity to thermal stress and reduces the threshold temperature for intermediate heat stress by 5°C. *Gantner et al. (2011)* pointed out that even in periods with lower temperatures when problems could be caused by high relative humidity, the heat stress condition may occur. *Du Preez et al. (1990a)* determined in dairy cows reared in South Africa, the decrease of milk yield at THI higher than 72 (22°C at 100% RH, 25°C at 50% RH, or 28°C at 20% RH). *Casa and Ravelo*

(2003) also determined significant decrease in milk production, in amount of 6% (9%) depending on the region, during the warmer months in Argentina. *Bouraoui et al. (2002)* reported decrease of 0.41 kg of milk / day for each point increase of THI above 69. The threshold value of THI depend on a many effects, for instance, lactation stage, parity, level of milk production, breed, breeding region, individual susceptibility to heat stress, etc. *(Kadzere et al. 2002, Bohmanova 2006, Collier et al. 2006, Hansen 2013, Gantner et al. 2017)*. For example, *Bouraoui et al. (2002)* put the threshold on 65-69, *Bernabucci et al. (2010)* as well as *Collier and Hall (2012)* on 68, *Du Preez et al. (1990a, b)* on 72, while *Bohmanova et al. (2007)* depending on region defined threshold THI value 72 in Georgia, and 74 in Arizona. *West (2003)* determined a reduction in DMI by 0.85 kg with every 1°C rise in air temperature above a cow's thermoneutral zone, therefore this decrease in intake accounts approximately 36% of the decrease in milk production. *Spiers et al. (2004)* notified that milk yield decreases by 0.41 kg/cow/day for each THI unit increase of above 69, within a day after initiation of heat stress, feed intake decreased, while after 2 days of HS milk yield decreased. *Gaafar et al. (2011)* determined that increasing of THI in the winter season from 59.82 to 78.53 in the summer season, HS reduced total (305 days) and daily milk yield by 39.00%, 31.40% and 29.84%, relatively. According to *Baumgard and Rhoads (2013)*, drop in milk production up to 50% in dairy animals might be due to reduced feed intake. *Lambertz et al. (2014)* pointed out that the difference in defined threshold values could be due to better adapted cows, farm management or housing.

Conclusion

Based on the conducted research, the negative effect of the increase of microclimate parameters on daily milk production in all cows regardless the breed and breeding region could be pointed out. Also, variability in daily production traits due to cow's breed, parity as well as breeding region as well as variability of microclimate parameters in the barns due to season and breeding region was found. Since genetic evaluation and selection of dairy cattle for heat resistance is only long-term method for heat stress managing, determined effect will be taken into account in the statistical model for estimation of genetic parameters and breeding values for heat resistance in dairy cattle.

Analiza proizvodnih karakteristika i mikroklimatskih parametara na farmama za proizvodnju mleka

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Rezime

Cilj istraživanja je bio određivanje varijabilnosti proizvodnih osobina (dnevni prinos i sastav mleka) i mikroklimatskih parametara (temperatura i vlažnost okoline) u objektima za držanje krava za proizvodnju mleka; kao i korelacija između analiziranih grupa osobina; 1.636.192 zapisa za grla simentalske rase i 1.275.713 zapisa test dana grla holštajn rase. Izvršene analize pokazuju veliku varijabilnost proizvodnih osobina zbog rase krava, pariteta kao i odgajivačkog regiona. Takođe je utvrđena velika varijabilnost mikroklimatskih parametara u objektima zbog sezone i odgajivačkog regiona. Pored toga, utvrđene su statistički vrlo značajne ($p<0,001$) korelacije između proizvodnih svojstava i parametara mikroklime. Konačno, negativan uticaj neadekvatne mikroklime na svakodnevnu proizvodnju mleka utvrđen je kod obe rase u svim odgajivačkim regionima. Pošto je genetska procena i selekcija mlečnih goveda na otpornost na visoke temperature sredine samo dugoročna metoda za upravljanje toplotnim stresom, utvrđeni efekat biće uzet u obzir u statističkom modelu za procenu genetskih parametara i odgajivačkih vrednosti.

Ključne reči: proizvodne osobine, mlečne krave, parametri mikroklime

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TYPOLOGICAL ASSESSMENT OF DAIRY FARMS SYSTEMS IN SEMI-ARID MEDITERRANEAN REGION OF WESTERN ALGERIA

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Abstract: The present study aimed to characterize the dairy cattle farming systems in semi arid region in western Algeria. A typology of the farms was established following the description of livestock dairy farming practices and the assessment of their contribution to farm efficiency. The enquiry was conducted on 60 dairy farms during 2018-2019 agricultural campaign to determine structural, technical and economic parameters. The Results show a large diversity of farmer's strategies, particularly in feeding and economic indicators. The statistical analysis has identified 3 groups of farms. The first group contains 12 farms produce average milk yield about 4120 kg and promote use of forages. The participation of concentrates in total dry matter ingestion (DMI) is about 45.3 %, the average costs of milk production is of 37.1 DA/ liter≈0.52 € and charge of food in total production costs in the order of 62.8 %. 32 dairy farms of second group are characterized by average milk yields 3240 kg and the contribution of concentrated foods represents 49.2 % of total DMI. The cost of liter of milk is about 42.7 DA≈0.60 € and food costs in order of 68.7 % of total production costs. The third group contains 16 dairy farms whose illustrates farms with a significant contribution of concentrates in the global feed balance (54.3 % of total DMI). These concentrated foods were poorly converted into milk as recorded yields are the lowest (2010 kg). Production costs of liter milk and the percentage price of food in total cost production were respectively highest (49.4 DA≈0.69 €) and (80.2 %). The results of this typology indicate the diversity of dairy farms systems in semi-arid region in North Africa, which must be taken to ensure the profitability and sustainability of farms identified. The socio-economic factors are behind the genesis of sample farms, the technical feeding and rationing and no diversification of forage calendar make clear the variations in groups of dairy husbandry. To guarantee sustainability development of typological groups, a specific measure,

particularly in feeding management, will be applied for different livestock systems identified.

Key words: typology, livestock cattle, technical parameter, production costs, semi arid land.

Introduction

The dairy livestock policy in Algeria depends on a systematic knowledge of livestock systems, identifying the weak links in its technical-economic efficiency and finding compromises in terms of public aid to the different actors of the livestock sector of milk supply chain to improve its output. The milk sector is currently in a critical phase, with insufficient local production, aggravated by a very low collection rate and increase in prices of livestock inputs in international markets. Consequently, several actions are being taken by the public authorities to reduce this deficit and the latest one is a "national program for the rehabilitation of milk production" *(Cherfaoui et al 2003).* According to *Kacimi (2013)* and *Merdaci et al. (2018),* consumption model of milk, is estimated at 147 liters/capita/year, which ranks Algeria as a country of major consumption of milk when compared to Maghreb state (Tunisia 83 liters, Morocco 64 liters). The programs to intensify milk production have not achieved the expected objectives *(Ghozlane et al., 2010).* Today, with a herd estimated at 1.9 million heads of cattle, including nearly one million dairy cows, domestic increasing demand for milk is not yet satisfied *(Kaouche et al., 2015).* The strategies applied to imports milk powder to fill the gap; were a major constraint on the development of local production. Through analyze of the Algerian milk sector *(Djermoun (2011)* and *Brabez (2012)* indicate a weakness of the production and the insufficiency of collection which explain the very low rate of integration compared to the transformation system. According to *Benyoucef (2005),* the main environmental factors that hinder the development of the dairy sector are socio-economic, agro climatic, sanitary, which constitute constraints to the development of animal productions, and organizational, related to livestock systems that are mostly extensive. The dairy farming systems remains a kind of speculation that is difficult to manage given the diversity of parameters that are linked to it. Very few aspects of dairy farming systems have been studied in semi arid region in western Algeria with an overview approach, as systemic studies were applied successfully to assess animal productions projects in other regions of developing and underdeveloped countries *(Landais, 1983; Srairi, 2003).* In addition, *Roeleveld and Van den Broek (1996)* emphasized the important role for livestock performances diagnosis, as a preliminary step to any promoting project, especially in underdeveloped countries. *Girard et al.,(2001)* and *Sairi (2003)* indicate that systemic approach based on husbandry practices can also be an

efficient way to examine the relations of farms to space utilization and time, which could be of significant interest for understanding farms evolution.

The present article aims to analyze dairy farms systems through a typological characterization of the producers involved in milk production, investigation of different practices and strategies in place to manage the units surveyed and finally, detection of constraints and potentialities of current systems. In context of very limited references on dairy farms in semi-arid Mediterranean region of western Algeria, typological characterization would be a practical tool for more development effort in the dairy cattle systems at the Mediterranean regional scale, as it would allow the implementation of adapted measures to targeted groups of farmers.

Materials and Methods

The study area is located in the center of Mascara town, limited in the North by the mountains of Béni-Chougrane, in South by the mountains of Saïda; in west by the mountains of Bou-Hanifia and in East by the Tighennif plateau. It covers 12 municipalities, with a total area of 1401 Km^2 (27. 3 % of the total area of Mascara) and a density of population of 181 habitants / km^2. It receives on average 450 mm / year with semi arid climate. The total number of farms is around of 11624 divided into 3 categories of status. The distribution of farms shows the dominance of private farms in number 8165 farms which represents 70 %, with an area of 45568 ha, but the collective farms (EAC) accounted for 16 %, with an area of 38157 ha, in number 1890 collective farms. As well as EAI (individual farms) number of 1569 exploitation, represent 14%, with an area of 5217 ha. The Province of Mascara is one of the west regions that has benefited from a large financial envelope of the development program of the dairy cattle sector. These effects remain poorly evaluated. Indeed, no study has been conducted to determine the situation of dairy cattle breeding in relation to the practices of the farmers.

Data collection and statistical analysis

A benchmark survey of dairy cattle breeders was conducted during 2018-2019 agricultural campaign. The overall sample of our study consists of 60 randomly selected cattle farms out of a total of 1011 dairy cattle farms with 6722 cows that have a sanitary approval issued by the veterinary services of Agricultural Direction. All breeders were interviewed and their flock performances were followed-up. The data collected during the monitoring of farms surveyed treat the structural (surface, herds, agricultural surface, and equipment), management (feeding resource) and technical economic indicators. The estimation of rations was based on the quantities of forages and concentrates in the ration distributed to

the dairy cows. Nutrient intakes were determined according to data given by INRA (2007). A typology of cattle dairy farming systems was identified from collected data, the statistical analyzes of data were performed using the Statistica 8.0 software (2008). A total of 10 quantitative parameters were identified to describe dairy farms and their activities (table 1).

The observations were divided into three main parts. The first one covered cattle farms structural parameters (herd, agricultural surface, equipment), while the second dealt with dairy cattle feeding and cows' management. The third part investigated into economic results of dairy herds, after the analysis of total inputs and global animal sales (milk, cattle and manure). A principal component analysis (PCA) was used to detect the most important variables characterizing farms sample. A typology made of 3 groups was finally retained to synthesize the global diversity of dairy farming in this region, assuming that sample gives an acceptable representation of the 1011 cattle farms in the region.

Table 1. Parameters used to describe sample dairy farms

Variables	Abbreviation
Surface Arable Land use	ARL
Forage Land (ha)	FOL
Number of Cows	NCW
Average production (kg milk per cow per year)	APM
Energy from concentrates /kg of milk (UFL)	UFL c/kg milk
Forage units milk concentrates per cow	UFL c/cow
Share of concentrates in total ration (% total DMI)	SCR
Food cost total inputs	FCT
Production Cost of 1 liter of milk (DA)	PCM
Benefit per cow (DA)	BC

Results and discussion

Dairy farm characteristics

The parameters that characterize the dairy farms are illustrated in table 2. Surveyed dairy farms are characterized by an average land use of 11.6±39.4 ha per farm. Because of variability in structural parameters between sampled farms (from 0.5 ha to 35 ha), standard deviation (39.4 ha) was superior to mean value for this parameter. More than 65 % of farmers use their entire useful agricultural land for forage crops, mainly dry forages such as oats and barley and alfalfa. The study included a total of 312 heads of dairy cows with an average of 10.4±0.65 cows per farm and an average density of 3.2 cows/ha of forage. As for arable land, there was variability in cattle number per farm due to the selection of structural parameters in our sample of different types of dairy farms. Genetic structure was dominated by

imported breeds (Frisonne Pie noir 94 percent of total cattle and Montbeliarde 6 percent). Mean milk yield per cow was 3400±1250 kg. The analysis of cattle feeding showed that forage represented 51.6±48.3 percent of the energy ingested by cows. The base feed consists essentially of oat hay and straw and the practice of silage is absent. Grazing is practiced on natural grass lands and in cereal fallow after the harvest.

Concentrates are represented by industrial compound feed specially made for dairy cows. They are distributed in various quantities for all farms, from 5.5 to 10 kg per cow per day. Feed costs were up to an average of 85 percent of total inputs. This important use of concentrates often resulted in their abuse, as they contributed to maintenance requirements, in a situation when forages were absent and with frequent unbalanced rations. Economic results of the dairy farms were characterized by wide variations, from positive to deficit. When average profitability generated by one cow was 25.850 DA (approximately 185 Euros), it fluctuated from -55.800 to 163.200 DA.

Table 2. Characteristics of sample dairy farms

Parameters	Min	Average ± SD	Max
ARL (ha)	0.5	11.6 ± 39.4	35
FOL (ha)	0.25	7.3 ± 1.34	14
NCW	4	10.4 ± 0.65	27
APM	2070	3400 ± 1250	5950
SCR (%)	9.5	51.6 ± 48.3	81
UFLc/kg milk	0.38	0.51	0.60
UFLc Kg/cow	5	6.5	9.5
FCT	47.5	85.0 ± 20,7	100
PCM (DA)	36	44.6 ± 6.3	46
BC (DA)	-55.800	25.850	163.200
1 DA	=0. 14 €		

Typology of farms according to their characteristics

The purpose of the multivariate statistical analysis is to identify the groups of dairy farms that are technically identical and to create homogenous groups of sample surveyed in relation to predominant variables. Results of PCA showed that 3 axis accounted for 52.4 percent of total variation in the farms sample **(**table 3**)**.

Table 3. Results of PCA and axis of variation determined

Axis	Variables	Correlation r to axis	Total variability (%)
Axis 1	- ARL - NCW - FOL	0.72 0.78 0.55	26.7
Axis 2	- UFLcc/cow - UFLcc/kg milk - SCR	-0.58 -0.61 -0.59	16.1
Axis 3	- APM - BC (DA) - PCM (DA) - FCT (DA)	0.32 - 0.40 - 0.65 - 0,41	9,6

The correlation between chosen variables and the most important factors indicates that the variables are agricultural use land, number of cows and average milk production (structure parameters); the forage units milk concentrates per cow, forage units milk concentrates per kg of milk and forage / concentrates in energy balance (variables related to food strategy); benefit per cow, production cost of liter of milk and food cost total inputs (variables related to management settings of milk production and the production economics). The first axis accounts for 26.7 % of the total variation and is positively correlated to the variables ARL (r =0.72), NCW (r =0.78) and to FOL (r=0.55). This axis differentiates between groups with important structural parameter and farmer's managed use agricultural land for crops with opposite characteristics. The second axis accounts for 16.1 % of the total variation and is negatively correlated to the variable UFLc/cow (r = - 0.58), UFLc/kg milk (r = - 0.61) and SCR (r= - 0, 59). This axis provides information on the possibilities of valorizing the energy resources of concentrated foods for dairy production and the ratio of energy use of forage/concentrates.

Farming systems are usually defined through the interactions of breeders, herds and environmental conditions and resources *(Lhoste, 1984*; *Srairi, 2003).*The multivariate analysis conducted in this study showed that variables reflecting breeding practices, feeding strategies and cattle sales, were predominant. The characteristics of three typological groups are presented in Table 4 and Figure 1.

Table 4. Characteristics of groups identified

Groups Parameters	1	2	3	Average
N.of farms	12	32	16	60
ARL (ha)	20,4	8,6	2,2	11,6
FOL (ha)	12,2	4,3	1,25	7,3
NCW	16,3	10.1	6.2	10,4
APM (kg)	4120	3240	2010	3400
SCR	45.3	49.2	54.3	51,6
UFLcc/kg milk	0.34	0.45	0.56	0.51
UFLcc/cow	5.5	7,6	9,7	6,5
FCT (%)	62.8	68.7	80.2	85,0
PCM (DA)	37.1	42.7	49.4	44.6
BC (DA) Significance	121.300[a]	85.100[b]	-10.700[c]	25.850

[a, b, c] Groups without common superscript differ significantly (P<0.005).

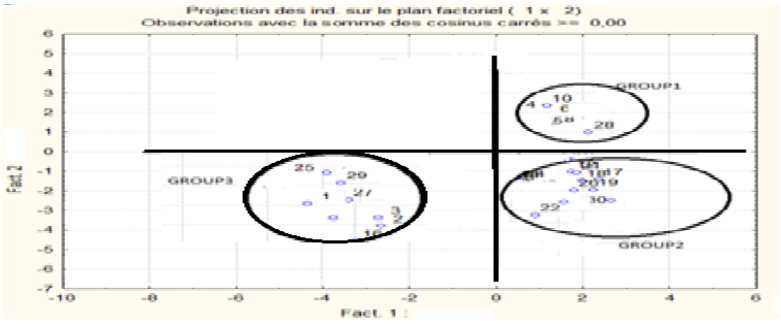

Figure1. **Graphical representation of farmers groups**

The first typology group, contains 12 farms, which favors forages compared to concentrates in the energy balance of their flock (45.3 percent of forage/concentrates in energy balance). Food cost total inputs are minimal (62.8 percent of total inputs), due to the low cost of forage production. The benefit per cow is positive (121.300 DA), as milk yield per cow is higher than the average (4120 compared to 3400 kg). The production cost of milk is 37.1 DA. This is a group of breeders that characterizes the start of specialization in the field of dairy bovine milk production. This is the group of farms considered as privileged group in milk production with a good feed management to cover the needs of the animals. The second group is represented with 32 farms, "medium farms characterized by milk yields below average (3240 kg). Concentrates in the energy balance represent just 49.2 % of DMI. These concentrates were poorly converted into milk as yields were recorded under average of farms simple. This group of farms records intermediary average production costs (42.7 DA/liter of milk) and food cost total inputs (68.7 %). The benefit per cow is positive (85.100 DA).

The 3rd group containing 16 farms, "small's farms", whose main characteristics are low average yield (2010 kg) and the elevated cost of production (49.4 DA/liter). A significant concentrates contribution in the global energy balance (80.2 % of DMI). These concentrates were poorly converted into milk as yields were recorded as the lowest and the benefit per cow is negative (- 10.700 DA). The results of this study confirm the importance of the effect of diet on the diversity of farming systems in the study area.

Discussion

In a context of absent references on dairy practices and economic indicator in interior region of western Algeria, this investigation of 60 dairy livestock farms in semi-arid Mediterranean region, has confirmed a large diversity of groups dairy farming. It can be explained mainly by strategies adopted by breeders to manage livestock and search technical-economic scale acceptable. All farms surveyed have dairy cows with high genetic performances (imported cows, Pie Noir and Pie rouge), average milk yield per cow remain weak (3400 kg) with a wide variation from 2070 to 5950 kg, and gross margin per cow varies from negative situations to positive ones. Multivariate statistical analyses have allowed the identification of three different groups of farmers, based on milk yield per cow, feeding strategies and economic parameters. The contribution of concentrates in the feed balance indicates a significant effect in dairy production 51. 6 % of DM intake. According to *Kadi et al. (2007)* the dairy farms in Tizi ouzou region use of concentrates were practices in all farms with varying degree. These feeding practice to use concentrate were inadequately converted into milk as recorded yields are the lowest (3400 kg). Production Cost of 1 liter of milk are uppermost (44.6 DA ≈ 0.62 €) and relation price of food/total cost of production is very elevated (average 75 %). A similar situation to ours were signaled by *Madani et al. (2004)* in semi-arid region with 42 and 53% of DMI and *Ghozlane et al. (2009)* in the farms of Eastern Algeria 40.9 and 70.5 % of DMI. For intensive farms dairy in Morocco, *Srairi and Kessab (1998)* a maximum contribution was signaled 73.1 % and *Srairi and Khattabi (2001)* rapport 72.9 %. According to *Kaouche et al. (2015)* in the north center region of Algeria an average of 42.4 % of DM intake lower then to our results. As a result there are areas for development via land reorganization and the adoption of well feeding practices in order to ensure the profitability and sustainability of farms identified in this study. The variability of milk yield found in our studies is largely related to the structural and practice management for the simple farms and it was lower than obtained by *(Kaouche et al, 2012)* in the farms in the region of Médéa in Algeria. Our results for the production prices is higher than signaled by *Ghozlane et al. (2009), Kaouche et al. (2015)* in dairy farms in Algeria. The elevated production prices observed largely on farms where the

concentrate was used at a rate higher than 50 % of total dry matter intake by cows and the results showed that practically in interval between 50 to 70 % of the cost of production of one liter of raw milk is allocated to food. However the difference between the sale price and the production cost is compensated by the help of the State estimated at 12 DA for each liter of milk produced by the farmer and 1 DA additional for each gram of fat beyond 34 g/liter.

For development perspectives, it is obvious that adapted research to dairy farms in interior plain region is immediately required in west Algeria. Technical recommendation in feeding strategies and adapted rations with calendar forager, complementation with concentrates, diversification of forages species and integrate conservation by ensiling means should be efficient. Since concentrates are widely used, it is mainly their mixing in adapted formulas to variable forages that could provide significant results. Prophylactic methods should also be set up for various parasitic diseases, in a context where few herds get preventive treatments.

All farms of the study area should be handled, with a special technical economic reference to group1. Extension of feed formulation techniques would probably have significant results. However, choosing relevant farmers (educated and motivated ones) is a necessary condition to achieve success, as pointed out by *Roelevled and Van Den Broek (1996).* Then, those farmers could show the way to others. This should be considered properly by development decision-makers.

Conclusions

The typological assessment of surveyed farms shows a diversity of farming systems in semi-arid region of west Algeria with different constraint related to structural and technical parameters and their elimination need an arsenal of human and financial resources. Historic and social factors behind the genesis of such farms and additionally technical organization of alimentation and reproduction explain the variations between the groups of farms identified. In general, groups 1, of farms surveyed, illustrate higher milk yields (4120 kg) and lowest cost of liter milk production. The low yields under the average sample (3240 and 2010 kg) for the 2^{nd} and 3^{rd} group, may be due to the excessive use of concentrates that are not valued in their entirety, linked with substantial purchases of fodder that are inadequately exploited in the absence of rationing and food formulations, which led to important costs.

In addition the performance of dairy farms are low, while 98 % of the cows are imported and consequently of high genetic value. For all farms, the constraints consist in the first place food factor which represents the major handicap of the entire dairy production farms. It was concluded, that this diversity of farming systems should be taken into account for development purposes, as specific measures, especially in the field of cattle feeding, need to be applied to each one of

the livestock systems identified, to guarantee their sustainability. The generalization of uniformed promoting programs should thus be avoided, as each group is characterized by specific technical extension requirements. So there are areas for improvement through the reorganization of land use in order to dimension the farms with sufficient forage area, improvement of forages calendar with diversification of species, and integrate silage practice food rationing and formulations in order to make sure the technical economic productivity and sustainability of farms identified in this study.

Tipološka procena farmi za proizvodnju mleka u polu-sušnom mediteranskom regionu zapadnog Alžira

Houari Yerou, Abdelkader Homrani, Abdelkader Benhanassali, Daho Boussedra

Rezime

Ova studija imala je za cilj da okarakteriše sisteme uzgoja mlečnih goveda u polu-sušnom regionu zapadnog Alžira. Tipologija farmi uspostavljena je nakon opisa odgajivačke prakse i procene njihovog doprinosa efikasnosti farmi. Istraživanje je sprovedeno na 60 farmi za proizvodnju mleka tokom poljoprivredne sezone 2018-2019 radi utvrđivanja strukturnih, tehničkih i ekonomskih parametara. Rezultati pokazuju veliku raznolikost poljoprivrednih strategija, posebno u pogledu ishrane i ekonomskih pokazatelja. Statističkom analizom su identifikovane 3 grupe gazdinstava. Prva grupa sadrži 12 farmi koje imaju prosečan prinos mleka od oko 4120 kg i promovišu upotrebu krmiva. Učešće koncentrata u ukupnom unošenju suve materije (DMI) iznosi oko 45,3%, prosečni troškovi proizvodnje mleka su 37,1 DA / l ≈ 0,52 €, a udeo hrane u ukupnim troškovima proizvodnje od 62,8%. Drugu grupu koja uključuje 32 farme za proizvodnju mleka karakteriše prosečni prinos mleka od 3240 kg, a udeo koncentrovane hrane je 49,2% ukupnog unosa suve materije (DMI). Trošak litra mleka je oko 42,7 DA ≈ 0,60 €, a troškovi hrane čine 68,7% ukupnih troškova proizvodnje. Treća grupa sadrži 16 farmi za proizvodnju mleka koje predstavljaju farme sa značajnim doprinosom koncentrata u ukupnoj stočnoj hrani (54,3% ukupnog unosa suve materije - DMI). Ova koncentrovana hrana slabo je pretvorena u mleko, jer su zabeleženi prinosi najniži (2010 kg). Proizvodni troškovi 1l mleka i udeo troška hrane u ukupnim troškovima proizvodnje bili su respektivno najveći (49,4 DA ≈ 0,69 €) i (80,2%). Rezultati ove tipologije ukazuju na raznolikost sistema mlečnih farmi u polu-sušnom regionu Severne Afrike, šta se mora preduzeti kako bi se osigurala isplativost i održivost ovih farmi. Društveno-ekonomski faktori se nalaze u pozadini izbora farmi, tehnička rešenja u ishrani i obročavanje i odsustvo diverzifikacija u proizvodnji krmne stočne hrane odražavaju razlike u grupama farmi za proizvodnju mleka.

Kako bi se osigurao razvoj održivosti tipoloških grupa, primenjivaće se posebna mera, posebno u menadžmentu ishrane, za različite identifikovane sisteme odgoja stoke.

Ključne reči: tipologija, goveda, tehnički parametar, troškovi proizvodnje, polusušna teritorija.

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ESTIMATION OF GROWTH TRAITS HERITABILITY COEFFICIENTS IN SHEEP

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Original scientific paper

Abstract: The objective of this research paper was to estimate heritability coefficients (heritability) of growth traits in the lambs of indigenous Sjenicka Pramenka breed. The research was conducted on a sample which included 421 lambs the descendants of 15 sires and 187 sheep-dams, raised on 3 private farms in Kolubarski district, Serbia. The effect of fixed factors was studied while the values of heritability coefficients were estimated within the frame of SAS software package. A statistically highly significant (**=P<0.01) effect on studied traits had following parameters: sex, year of lambing, type of lambing, farm and method of applied reproductive technology. By means of REML method and using the sire model the values of heritability coefficients were determined for the following traits: average lamb birth weight (BW0), average lamb body weight at 30 days (BW30) and average lamb body weight at 90 days (BW90) being: 0.0355; 0.4642 and 0.3018, respectively.

Key words: lambs, growth, heritability, Sjenicka Pramenka sheep.

Introduction

In total value of agricultural production in 2017. livestock production accounted for 38.3%, the highest rise being recorded in sheep breeding (7.4%) what makes this branch of agriculture very important for our country. Regarding the breed composition the largest part of sheep population is made of indigenous Pramenka sheep breed, in central Europe known as Zackel (*Drăgănescu and Grosu, 2010*), of combined direction of production (meat-milk-wool) within which stock the largest number of animals belong to Sjenica strain. Besides the size of sheep population, sheep fertility (number of lambs in litter, number of lambing per

year), along with nutrition, fattening and lamb slaughter traits (*Senčić et al., 2010*) has an important effect on meat production as well. Production of lamb meat obtained from young lambs up to 90 days old, and of the carcass weight of 10 to 12 kg, i.e. about 25 kg live weight, is a predominant one. By improvement aimed at increasing the production of meat the obtaining of lambs with higher daily weight gain (over 300 g), higher final body weight at 90 days (over 28 kg), as well as higher dressing percentage of more than 58% (*Petrović et al., 2013*) should be rendered possible. On the other hand, by breeding purebred animals a high quality meat is obtained as a result of breeding and nutrition in a preserved and abundant natural environment such as it is in a hilly-mountainous region of our country.

In order that selection be conducted successfully and for the purpose of obtaining higher production of sheep meat it seems necessary to know external factors which quantity and quality of meat (housing, nutrition, care) depend on as well as genetic parameters (heritability, repeatability, genetic correlations) which have an economic effect on production.

Type of birth, lamb sex, year of birth, age and weight of dams statistically significantly affected body weight of Sönmez lambs *(Taskin et al., 2012),* Afshari lambs *(Latifi and Mohammadi, 2018),* and Baluchi lambs *(Abbasi et al., 2012).*

With high values of heritability coefficients known it is possible, on the basis of phenotypic expressiveness, to predict genetic value of an individual what is deemed important in selection programmes. Heritability values are characteristic for a population since genetic variance depends on segregation of alleles which affect the trait, on frequencies of alleles, on the effects and mode of action of genes, as well as on variations of the environment which can be different in different populations *(Visscher et al., 2008).*

The values of heritability coefficient for growth trait ranged from 0.03 (*Perez et al., 2017)* for body weight at birth in Romney Marsh lambs to 0.46 for the same trait in Menz breed as reported by *Gizaw et al. (2007),* while for body weight at weaning heritability value was 0.96 as calculated by *Perez et al. (2017)* for Hampshire breed.

Materials and Methods

Studying phenotypic variability and determining the values of heritability coefficients was conducted on a sample of 421 lambs which were descendants of 15 sires and 187 sheep-dams of Sjenicka Pramenka strain sheep. The animals were raised on 3 private farms in the region of Kolubarski district. Ewe-dams lambed in the period from early 2016. to the end of 2017. Synchronization and induction of oestrous were carried out on farm 1 and farm 2 on 131 animals, while the ewes on farm 3 were mated in season without application of hormones in reproduction. Induction and synchronization of oestrous in ewes was performed by application of

vaginal pessary (60 mg medroxy-progesterone acetate in the course of 12 days + 500 i.j. PMSG). The ewes on all three farms were 4.8 years old on average. A calendar year was divided into 4 seasons (quarters), each season consisting of 3 months: winter (December, January, February), spring (March, April, May), summer (June, July, August) and autumn (September, October, November).

The research included following lamb body weights: an average 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). Principal statistical parameters of phenotypic expression and variability of studied traits were calculated by means of standard statistical procedures by help of PROC MEANS procedure within SAS programme package (*SAS Inst., Inc., Cary, NC*).

The effect of fixed factors was studied by help of GLM procedure within SAS programme package (*SAS Inst., Inc., Cary, NC*). During research a fixed model was used which incorporated the research of the effect such as follows: dam`s age (12 classes in relation to the age of animals in years), type of lambing (singles and twins), year and season of lambing, lamb sex, farm and an applied method of reproductive technology (induction and synchronization of oestrous outside season and natural mating in season).

An applied fixed model was such as follows:

$Y_{ijklmno} = \mu + F_i + G_j + Z_k + S_l + T_m + P_n + R_o + e_{ijklmno}$

In which:

$Y_{ijklmno}$- is a phenotypic expression of a studied trait

μ- population general average

F_i- fixed effect of i farm (i=1, 2, 3)

G_j- fixed effect of j year of birth (j=2016, 2017)

Z_k- fixed effect of k lambing season (k=1, 2, 3, 4)

S_l- fixed effect of l dam`s age (l=1, 2, 3...12)

T_m- fixed effect of m type of birth (m=1, 2)

P_n- fixed effect of n lamb`s sex (n=1, 2)

R_o- fixed effect of o method of reproductive technology (o=1, 2)

$e_{ijklmno}$- random error.

Variances of studied traits were calculated by means of VARCOMP procedure, REML method by using the ”SAS/STAT“ programme package **(***SAS Inst., Inc., Cary, NC***)**. Following mixed model was used:

$Y_{ijklmnop} = \mu + F_i + G_j + Z_k + S_l + T_m + P_n + R_o + o_p + e_{ijklmnop}$

In which:

$Y_{ijklmnop}$- is a phenotypic expression of a studied trait

μ- population general average

F_i- fixed effect of i farm (i=1, 2, 3)

G_j- fixed effect of j year of birth (j=2016, 2017)

Z_k- fixed effect of k lambing season (k=1, 2, 3, 4)

S_l- fixed effect of l dam`s age (l=1, 2, 3...12)

T_m- fixed effect of m type of birth (m=1, 2)
P_n- fixed effect of n lamb`s sex (n=1, 2)
R_o- fixed effect of o method of reproductive technology (o=1, 2)
o_p- random effect of p sire (p=1, 2, 3...15)
$e_{ijklmnop}$- random error.

Heritability coefficients were calculated by a method of intra-class correlation of sires` half-sibs, i.e. out of sires` variance components:

$$h^2 = \frac{4 * \sigma^2_{IO}}{\sigma^2_{IO} + \sigma^2_{UO}}$$

where
h^2- is a heritability coefficient
σ^2_{IO}- variance between sires
σ^2_{UO}- variance inside sires.

Heritability errors were calculated by means of a standard procedure.

Results and Discussion

Table 1. Average values and variability of studied traits

Traits	n	x̄	SD	Variance	Min	Max	CV(%)
BW0, kg	421	4.26	0.59	0.35	2.95	5.50	13.83
BW30, kg	421	12.76	1.32	1.75	10.00	15.80	10.35
BW90, kg	419	30.19	2.22	4.95	25.00	36.00	7.37

*BW0= birth weight; BW30= body weight at 30 days; BW90= body weight at 90 days.

An average lamb body weights at birth, at 30 days and at 90 days were 4.26 kg, 12.76 kg, and 30.19 kg, respectively (tab. 1). Calculated average values are much higher in relation to those calculated by *Vujić (1997)* in the same Pramenka strain where in the average body weights of lambs at birth, at 30 days, and at 90 days were 3.81 kg, 9.43 kg, and 22.13 kg, respectively. Higher body weight can be a consequence of the application of selection in Sjenicka Pramenka population as well as of modern technological solutions which improved the conditions of raising. *Petrović et al. (2009)* point out that lamb`s weight at birth plays an important role in accomplishing profitable production since not only live weight gain but also lamb`s vitality and mortality depend on the initial body weight.

Table 2 shows the levels of significance of the influence of the effects included in the model on studied lamb growth traits in Sjenicka Pramenka sheep.

Table 2. Values of F- test for studied factors

Traits	Factors							
	Dam`s age (year)	Lambing season	Lambing year	Lambing type	Sex	Farm	Method of reproductive technology	R^2
BW0	1.43^{ns}	1.22^{ns}	15.91^{**}	493.58^{**}	2.44^{ns}	55.13^{**}	96.67^{**}	0.89
BW30	0.26^{ns}	0.44^{ns}	3.87^{*}	115.25^{**}	5.97^{*}	6.15^{*}	8.52^{**}	0.94
BW90	5.47^{*}	0.66^{ns}	129.88^{**}	252.32^{**}	21.09^{**}	0.88^{ns}	1.57^{ns}	0.97

^{nz}=P>0.05; *=P<0.05; **=P<0.01; R^2= coefficient of determination.

Factors such as: sex, lambing year, lambing type, farm and method of applied reproductive technology had a statistically highly significant (**=P<0.01) effect on the traits. Lambing season did not statistically significantly affect studied traits because a larger number of ewes (70.1%) in the research underwent hormonal treatment, that is, synchronization of oestrous, so ewes lambed through out a whole year. Determination coefficients (R^2) show that by the effects included in the model, 0.89% to 0.97% of variability of studied growth traits can be explained.

Boujenane and Diallo (2016) came to the conclusion that dam`s age, type of birth, lamb`s sex and year of birth statistically significantly affected body weight at birth, at 30 days and at weaning in Sardi sheep. *Mekić et al. (2008)* reported results of development of Sjenicka Pramenka lambs from birth to the age of 90 days depending on the farm effect, sex and type of birth. According to the applied linear model general average for body weight at birth was 3.52 kg, at 30 days 8.72 kg and at 90 days 20-56 kg. A farm and birth type had a significant effect on studied lamb traits.

Table 3. Values of heritability (h^2) and standard errors of heritability (S_h^2) for growth traits in Sjenicka pramenka breed sheep

Traits	n	h^2	S_h^2
BW0	421	0.0355	0.0132
BW30		0.4642	0.1124
BW90	419	0.3018	0.0791

The growth traits in Sjenicka Pramenka lambs have low (0.0355 for body weight at birth), medium (0.3018 for lamb`s body weight at 90 days) and high values of heritability (0.4642 for body weight at 30 days).

Determined heritability values for body weight at birth are consistent with the values reported by *Perez et al. (2017)* in Katahdin breed (0.07±0.0015), *Boujenane and Diallo (2016)* in Sardi sheep (0.07±0.02), *Ozcan et al. (2005)* in Turkish Merino sheep (0.08), *Kastelic and Kompan (2007)* in lambs of Jezersko-

solcavska breed (0.078±0.035) and with *Haile et al. (2018)* who determined low heritability values during mating between Syrian and Turkish Avasi sheep (0.03±0.022 and 0.06±0.042). Medium heritability values for this trait were determined by *Baneh and Ahmadpanah (2018)* for local Iranian Ghezel breed (0.285) and by *Murphy et al. (2018)* 0.27 in crossbreds obtained by crossing the sheep dairy breed (Eastern-Friesian and Lacaune breed). Heritability value calculated for body weight at weaning corresponds to the values reported by *Zishiri et al. (2014)* for Dormer breed (0.28±0.02) and Merino landsheep (0.25±0.05), while it is higher than values obtained for Ile de France breed (0.14±0.04).

On the other hand, following authors determined higher heritability values for body weight at birth than at weaning: *Mirhoseini et al. (2015)* in Karakul sheep (0.21 and 0.10); *Miraei-Ashitani et al. (2007)* in Sangsari fat-tailed sheep (0.33±0.05 and 0.17±0.05), *Latifi and Mohammadi (2018)* and *Ghafouri-Kesbi and Eskandarinasab (2018)* in Iranian Afshari breed (0.11 and 0.08; 0.15 and 0.06).

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.

Conclusion

Low and medium heritability values for growth traits in lambs of Sjenicka Pramenka sheep show that by selection performed on the basis of performance and other conventional methods of selection the individuals with best genetic properties can be more difficult to identify what slows down genetic improvement, therefore the selection should be based on the estimation of animal breeding value. Moreover, in the next period the attention should be devoted to genetic markers and MAS selection (Marker Assisted Selection) when choosing the parents of future generations in order to obtain lambs with superior growth traits.

Procena koeficijenta naslednosti za osobine porasta kod ovaca

Krstina Zeljić, Dragan Stanojević, Vladan Bogdanović, Cvijan Mekić, Dragana Ružić-Muslić, Nevena Maksimović, Nenad Stojiljković

Rezime

Cilj rada bio je da se procene koeficijenti naslednosti (heritabilitet) osobina porasta kod jagnjadi sjeničke pramenke. Istraživanje je sprovedeno na uzorku od 421 jagnjadi, potomaka 15 očeva i 187 ovaca-majki sa 3 privatne farme u Kolubarskom okrugu.

Ispitan je uticaj fiksnih faktora i procenjene su vrednosti koeficijenata naslednosti u okviru SAS softverskog paketa. Visoko statistički značajan (**=P<0,01) uticaj na ispitivane osobine imali su: pol, godina jagnjenja, tip jagnjenja, farma i metod primenjene reproduktivne tehnologije.

Metodom intraklasne korelacije polusrodnika po ocu utvrđene su vrednosti koeficijenta naslednosti za osobine: prosečna telesna masa jagnjadi na rođenju (BW0), prosečna telesna masa jagnjadi sa 30 dana starosti (BW30) i prosečna telesna masa jagnjadi sa 90 dana starosti (BW90) i iznosile su: 0,0355; 0,4642 i 0,3018, respektivno.

Ključne reči: jagnjad, porast, heritabilitet, sjenička pramenka.

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PERFORMANCE RECORDS OF AUTOCHTHONOUS GOATS IN CENTRAL SERBIA

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Abstract: The purpose of this study was to determine status, number and present level of productivity of autochthonous goats raised in Central Serbia on smallholder farms. Study included quality breeding animals of Balkan and Serbian white goat breed registered in Central herd book. Productivity data were collected from regular annual performance recordings at 11 smallholder farms for 145 Balkan does (2-9 years of age) and 203 kids and 83 Serbian white does (2-10 years of age) and 109 kids. Traits recorded were as follows: body weight of does, body weight of kids at birth, at the age of 30 days and at weaning, prolificacy of does and milk production. The analysis showed the average body weight of does to be 43.07 kg for Balkan does and 47.42 kg for Serbian white does. Average body weight of kids at birth, 30 days of age and weaning was 2.22 kg, 6.87 kg and 15.71 kg, respectively for Balkan breed and 3.66 kg, 7.24 kg and 14.23 kg for Serbian white breed. Prolificacy was 140% in Balkan and 131% in Serbian white does. Among dairy production traits, following results were obtained for Balkan and Serbian white goat respectively: lactation length 199 and 229 days, total milk yield 257.89 kg and 459.49 kg, milk fat content 4.03% and 3.79%, milk protein content 3.06% and 3.35%. Number of quality breeding animals registered at Central herd book in 2018, as presented in Institute for Animal Husbandry's annual report for goats for Central Serbia in 2018, was 159 for Balkan and 138 for Serbian white goat. As these breeds represent a valuable and irreplaceable source of genetic variability, as well as very important cultural and traditional heritage and further emphasis should be on preserving and increasing their number.

Key words: goats, autochthonous, Central Serbia, productivity

Introduction

Goat breeding had a significant place and tradition in the Republic of Serbia before the Second World War. First of all, thanks to favourable natural environment, it was mostly represented as an extensive production, alongside the

sheep production, in the hilly-mountainous area in which half of the agricultural population lived. At the time, goat farming was predominantly based on breeding of domestic Balkan goat, breed of low production capacity, modest in terms of breeding conditions, but also very resistant. With the adoption of the Law on the Prohibition of Goat breeding in 1954 *(Anonymous, 1954)*, goat farming has become an unattractive and politically anathematized branch of livestock production, which negatively influenced the overall size of the goat population in Serbia, as well as the presence of the autochthonous goat breeds. Also, rapid industrialization, settlement of cities and the depopulation of villages, as well as the unfavourable economic situation in the country at the end of the 20th century, led to the almost complete abandonment of this type of livestock production, especially in mountain regions *(Maksimović et al., 2017)*.

In recent years attempts have been made to revitalize the goat production, primarily through the import of high-productive foreign breeds such as the Alpine and Saanen, which resulted in an intensification of goat production and increased productivity of goats. However, at the same time, autochthonous breeds were almost completely abandoned by farmers, due to their lower productivity which made them become uncompetitive to these high-productive breeds.

However, more recently, the great efforts of the global community are aimed at preserving world's biodiversity *(Nikolov, 2015)*, with farm animal genetic resources being an integral part of it. Indigenous breeds of all animal species represent a valuable and irreplaceable source of genetic variability, as well as a very significant cultural and traditional heritage. By raising awareness of the evident climatic changes, as well as the importance of the production of healthy high quality food, special attention is paid to the preservation of autochthonous breeds of farm animals.

Locally-adapted (autochthonous) goat breeds in central Serbia are especially suitable for breeding in marginal areas, in brisk-mountainous terrains, which are scarce in vegetation, where production is almost exclusively based on the use of natural pastures. This guarantees the high sustainability of local ecosystems, improves the role of agriculture in preserving the environment, and also provides the possibility of producing autochthonous traditional (typical) products. A "typical" product is a result of several factors including raw material, transformation process and sensory characteristics. All these peculiarities are closely related to the geographical origin and to the social and cultural traditions of the production area *(Scintu and Piredda, 2007)*.

There are two local goat breeds currently raised in Central Serbia, Balkan goat and Serbian white goat (also known as improved domestic goat), with Balkan goat being autochthonous breed and Serbian white basically being improved Balkan by crossing with Saanen bucks in order to improve milk yield. Both of these breeds are low productive breeds, but well adapted to modest conditions of care, housing and nutrition, usually raised in high lands and are considered

endangered although the real number of these animals is not known. For Balkan goat, the meat, i.e. quality kid carcass is the most important product *(Mioč et al., 2011)*, while Serbian white goat has higher milk production, but both breeds are used for combined production of both milk and meat. Balkan goat is also found in almost entire region of Balkan Peninsula and south-eastern Europe *(Bogdanović et al., 2010)* and domestic white goat is raised in former Yugoslavian republics, especially in Croatia *(Mioč et al., 2012)*.

Given the importance and impact that these breeds have on preserving local as well as global ecosystems and the environment, the objective of this study was to determine status, number and present level of productivity of autochthonous goats raised in Central Serbia on smallholder farms.

Material and Methods

Study included animals of Balkan and Serbian white goat breeds registered at Central heard book which are regularly under performance recording. Number of registered quality breeding animals of these breeds was taken from Institute for Animal Husbandry's annual report "Activities report and results of the control of realization of breeding programs in 2018" for goats in Central Serbia. Data for productivity control were collected from regular annual performance recordings at 7 smallholder farms with Balkan goats located in Zaječar and Nis district and 4 smallholder farms with Serbian white goats located in Belgrade, Zaječar and Rasina districts. Data were analysed for total of 145 Balkan does (2-9 years of age) and 203 kids and 83 Serbian white does (2-10 years of age) and 109 kids. For Serbian white the average flock size was 21 goats, with a range of 12 to 27. Animals were kept extensively, mostly at pasture, except for the winter, when they were kept indoors. Nutrition was primarily based on pasture (during warm part of the year) and meadow or alfalfa hay (during cold part of the year). Goats were bred throughout natural service.

Traits recorded were as follows: body weight of does, body weight of kids at birth, at the age of 30 days and at weaning (which is approximately the age of 90 – 120 days), prolificacy of does calculated as the percentage of number of kids born on total number of does delivered and milk production.

Among milk production traits, following traits have been analysed: the milk yield in full lactation, milk fat content, milk protein content and lactation duration (in days).

The milk recording was conducted by AT method, which was done in the time interval of 28-34 days, once in the morning and next time at evening, by official recorder *(International agreement, 2009)*. First recording was done 40 days after kidding. Milk components (fat and protein) were analysed using the ultrasonic milk analyser Ekomilk.

The collected data were analysed by the statistical package Statistica for Windows 7 (stat. Soft. Inc.). Obtained results were presented as mean±SE.

Results and Discussion

Table 1 shows number of quality breeding animals of Balkan and Serbian white goats under selection control, registered at Central herd book, for the period of 5 years.

Table 1. Number of goats under selection control in the period 2014 to 2018

Genotype/year	2014.	2015.	2016.	2017.	2018.
Balkan goat	37	129	154	121	159
Serbian White goat	155	150	116	145	138

Source: Activities report and results of the control of realization of breeding programs in 2018

As seen in Table 1 number of these animals was more-less consistent throughout five year period except for 2014 in which Balkan goat was quite less in number. According to the Institute for Animal Husbandry's annual report for goats for Central Serbia in 2018 there were total of 8,070 quality breeding goats under productivity control of all genotypes, which makes Balkan goat and Serbian white goat participating with only 1.97% and 1.71%. There is no data about total number of animals of these two breeds raised on Central Serbia territory, but this low percentage indicates that a majority of autochthonous goats still remain unsupervised and outside performance recording. This in turn reflects negatively in terms of insufficient knowledge of production abilities and which is most important, preservation of these breeds as valuable genetic resources.

Mean±SE for live weight of does, birth weight of kids, body weight of kids at the age of 30 days, body weight of kids at weaning and prolificacy of does are set out in Table 2.

Table 2. Body weight and prolificacy (Mean ± SE)

Traits/Breed	Balkan		Serbian white	
	N	Mean±SE	N	Mean±SE
BW of does (kg)	145	43.07±0.32	83	47.42±0.63
BW of kids at birth (kg)	203	2.22±0.04	109	2.66±0.04
BW of kids at 30 days of age (kg)	203	6.87±0.07	109	7.24±0.09
BW of kids at weaning (kg)	203	15.71±0.09	109	14.23±0.25
Prolificacy (mature does), %	140		131	

*BW – body weight

As shown in Table 1, Serbian white does were somewhat heavier with 47.42 kg live weight on average, compared to Balkan does, which weighted 43.07 kg on average. Body weight of kids was also a bit higher for Serbian white in first two control periods, but lower at the time of weaning, which can probably be attributed to perhaps different time of weaning. In extensive goat production, especially with local goat breeds, it is not uncommon to see prolonged period of weaning from 90 to 120 days or more of kids' age. As for prolificacy, Balkan does had higher rate of 140% on average compered to Serbian white with rate of 131%. *Žujović et al. (2007)* found optimal body mass of goats of Serbian White population to be from 40 to 47 kg in order to assure optimal production of milk and meat, but the authors also found birth weight of kids to be higher than in present study, with a range of 3.5 to 4.2 kg depending on body weight of does and type of birth of kids. According *to Mioč et al. (2012)* and *Mioč and Pavič (2002)* domestic white goat raised in Croatia has body weight of 35 to 45 kg, fecundity of 150 % on average and birth weight of kids of about 3 kg.

Research of *Ivanović et al. (2014)* showed average body weight of 44.7 kg for Balkan and 50.9 kg for Serbian white goats and *Memiši et al. (2009)* reported body weight of 2.7 kg and 13.62 kg for Balkan kids at birth and 90 days of age. *Mioč et al. (2011)* determined average body weight of Croatian Balkan goat kids to be 2.28 kg at birth and 23 kg at weaning (at the age of 186 days). As it can be seen from these literature data, present study showed similar values for live weight of both Balkan and Serbian white goat and birth weights of kids.

Milk performances including length of lactation, total milk yield, milk fat and milk protein content for Balkan and Serbian white goats in are presented in Tables 3 and 4 as mean±SE.

Table 3. Balkan goat milk traits according to the order of lactation (Mean ± SE)

Order of lactation	N	Lactation length, days	Total milk yield, kg	Milk fat, %	Milk protein, %
I	28	204	218.87±17.29	3.99±0.03	2.98±0.03
II	20	220	267.63±14.55	4.00±0.08	3.06±0.03
III	18	189	292.61±22.99	3.98±0.08	3.04±0.04
IV	9	211	339.75±32.30	4.21±0.04	3.16±0.03
V	19	203	279.85±16.73	4.10±0.04	3.14±0.03
VI	5	182	216.72±6.24	3.90±0.02	3.08±0.05
VII	13	160	202.15±7.50	4.05±0.03	3.06±0.02
Overall	112	199	257.89±8.31	4.03±0.02	3.06±0.01

Table 4. Serbian white goat milk traits according to the order of lactation (Mean ± SE)

Order of lactation	N	Lactation length, days	Total milk yield, kg	Milk fat, %	Milk protein, %
I	4	214	438.85±39.21	3.51±0.01	3.38±0.02
II	16	224	448.89±20.67	3.89±0.07	3.34±0.02
III	17	241	498.85±9.01	3.81±0.01	3.30±0.01
IV	5	249	465.84±11.39	3.93±0.10	3.32±0.02
V	15	226	469.86±11.55	3.76±0.05	3.38±0.03
VI	16	219	445.9±28.46	3.67±0.03	3.43±0.02
VII	5	238	432.94±9.70	3.98±0.09	3.29±0.02
Overall	78	229	459.49±6.52	3.79±0.02	3.35±0.01

As seen from Tables 3 and 4 total milk yield regardless of order of lactation was 257.89 kg for Balkan and 459.49 kg for Serbian white goat on average, in lactation of 199 and 229 days, respectively. Milk fat and milk protein content was 4.03% and 3.06% in milk of Balkan goat and 3.79% and 3.53% in milk of Serbian white goat. *Bogdanović et al. (2010)* reported average milk yield in Balkan goat of 378.46 kg with fat content of 3.71% in lactation of 256 day which is higher than milk yield obtained in present study. On contrary, *Memiši et al. (2004)* found milk yield in Balkan goat to be 178 kg with 3.68% of fat in lactation of 235 days. In study of *Zujović et al. (2010)* Serbian white goat had production of 283.61 kg of milk in I and 385.21 kg of milk in II lactation, which is less than in present study, but found higher content of fat (4.39%) and lower content of protein (3.10%). In study of *Žujović (1993)* average milk yield of 399.83 kg was determined for Serbian white goat in 277 day lactation. These varieties of presented results can arise from different rearing conditions of goats, as well as from perhaps different milk recording methods. Nonetheless, variability in milk traits can be exploited in positive direction throughout planed selection and better rearing. As for order of lactation, linear trend of increase in milk yield up to third or forth lactation and then decline toward seventh lactation was observed in both breeds, but those changes were very subtle in Serbian white goat. Similar results regarding the influence of order of lactation on dairy production in goats were obtained by *Bogdanović et al. (2010)*, *Memiši et al. (2011)* and *Marete et al. (2014)*.

Conclusion

From the data presented it can be concluded that there is a very small number of Balkan and Serbian white quality breeding goats registered in Central herd book, and therefore also a very small number of these animals under performance recordings. This in turn makes it difficult to determine realistic level

of productivity for these breeds. However, these breeds represent a valuable and irreplaceable source of genetic variability, as well as very important cultural and traditional heritage and further emphasis should be on preserving and increasing their number. Also, as seen from present data, variability of productive traits offers possibilities for improvement through selection and better rearing, which assures preservation of pure breeds.

Proizvodni parametri autohtonih rasa koza u Centralnoj Srbiji

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Rezime

Cilj istraživanja bio je da se utvrdi status, brojno stanje i postojeći nivo proizvodnosti autohtonih rasa koza gajenih na teritoriji Centralne Srbije na malim porodičnim gazdinstvima. U ispitivanje su bila uključena kvalitetna priplodna grla balkanske i srpske bele rase koza, upisana u Glavnu matičnu evidenciju. Brojno stanje umatičenih grla koza ove dve rase preuzeto je iz Stručnog izveštaja i rezultata sprovođenja odgajivačkog programa u 2018.godini. Proizvodni podaci su prikupljeni iz redovne godišnje kontrole proizvodnih svojstava koza sa 11 poljoprivrednih gazdinstava za 145 plotkinja i 203 jaradi balkanske rase, odnosno 83 plotkinje i 109 jaradi srpske bele rase. Plotkinje su bile uzrasta 2 do 10 godina, a jarad u uzrastu od rođenja do odlučenja (90 do 120 dana). Analizirane su sledeće osobine: telesna masa koza, telesna masa jaradi na rođenju, sa 30 dana uzrasta i pri odlučenju, plodnost koza i osobine mlečnosti (dužina laktacije, količina mleka za laktaciju, sadržaj mlečne masti i proteina). Analizom su utvrđene prosečne vredenosti telesne mase koza od 43,7 kg za balkansku rasu i 47,42 kg za srpsku belu rasu. Prosečne telesne mase jaradi na rođenju, sa 30 dana uzrasta i pri odlučenju bile su redom 2,22 kg, 6,87 kg i 15,71 kg kod balkanske rase, odnosno 3,66 kg, 7,24 kg i 14,23 kg kod srpske bele. Plodnost je u proseku bila 140% kod plotkinja balkanske koze, odnosno 131% kod plotkinja srpske bele koze. Prosečna mlečnost balkanske koze iznosila je 257,89 kg mleka u laktaciji od 199 dana, sa 4,03% mlečne masti i 3,06% proteina. Srpska bela koza imala je prosečnu mlečnost 459,49 kg u laktaciji od 229 dana, sa 3,79% mlečne masti i 3.35% proteina mleka. Broj kvalitetnih priplodnih grla upisanih u Glavnu matičnu evidenciju bio je 159 za balkansku rasu i 138 za srpsku belu kozu. S obzirom na mali broj koza ove dve rase koji se nalazi pod kontrolom proizvodnih svojstava teško je utvrditi realan nivo njihove produktivnosti. Ipak, ove rase predstavljaju vredan i nezamenljiv

izvor genetske varijabilnosti, kao i veoma važno kulturalno i tradicionalno nasleđe i naglasak bi trebalo staviti na njihovo očuvanje, kao i povećanje brojnog stanja.

Ključne reči: koze, autohtone rase, Centralna Srbija, produktivni parametri

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THE SHARE OF TISSUES IN THE PIG ROUND DEPENDING ON THE GENOTYPE, GENDER AND SEASON

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Original scientific paper

Abstract: The study included 201 offspring (108 castrated males and 93 females) of Landrace (L), Large White (LW) and Pietrain (P) sires. The studied animals were of following genotype: Landrace (L; n = 48); two breed crosses with 50:50 share of parental breeds (LWxL, n=32; and PxL, n=23), two breed crosses with 75% of paternal breed [Lx(♀LWxL), n=35] and [LWx(♀LxWL) n=38] and three breed crosses [Px(♀LWxL) n=25]. Animals included in this study were born during four seasons: winter (n=38), spring (n=65), summer (n=40) and autumn (n=58). Studies have shown that, at an average weight of warm carcass side of 81.20 kg, the highest average values for the weight of round (RW; 10.204 kg), the weight of intermuscular fatty tissue (RINT; 0.478 kg), bone tissue (RBT; 0.850 kg) and muscle tissue (RMT, 7.552 kg) in the round, were established in three-breed crosses of Px (LWxL) genotype compared to other genotypes. The least skin and subcutaneous fatty tissue (RST; 1.269 kg) was recorded in two breed crosses PxL. They had less skin and subcutaneous fatty tissue by 454 g and 467 grams, respectively, compared to two breed crosses (LWxL) and LWx (♀LxLW). Research has shown that there is a genotype on a farm that gives more muscle tissue in the round by 1.521 kg [Px (♀LWxL): LWx (♀LWxL)] with the same weight of warm carcass side, which is a very large difference. With the same average weight of warm carcass side, female animals had higher average weight of the round and yield of muscle tissue compared to male castrated animals. The effect of genotype ($P<0.001$) on all investigated traits was recorded, also the effect of the season of birth on the skin and subcutaneous fat tissue and on the weight of intermuscular fat in the round was recorded. The effect of sex/gender was significant ($P<0.01$) on the weight of skin and subcutaneous fat and on the weight

of the muscle tissues in the round but no significant effect on other tested properties (P> 0.05) was observed.

Key words: fatteners, fatty tissue, bone tissue, muscle tissue of the round

Introduction

Pigs have the highest level of accumulation of fat tissue in the carcass, of all the species of domestic animals. In the case of new-born piglets, the content of fat tissue in the carcass is only about 2% and its share in the carcass increases with the age of the animal. During lifetime of pigs, until the end of the fattening period, mainly the subcutaneous fat tissue is accumulated, which on average accounts for 60 to 70% of the total fat tissue in the body; the fat tissue of the body cavities makes up 10 to 15%, and intermuscular fat 20 to 35%. The content of intramuscular fat tissue in most industrial pig genotypes is between 2.5 and 3.5% *(Karolyi, 2007). Dević and Stamenković (2004)* have concluded that the selection/breeding can influence the content of the intramuscular fatty tissue, i.e. the content of fat in the meat.

In the studies of *Mason et al. (2005)* statistically significant differences (P<0.001) have been found for intramuscular fat content in ML (2.31:3.32%) between offspring of the Landrace and Duroc sires. As for the effect of sex on the amount of fat in the pig carcass, *Čepin and Žgur (2003)* state that uncastrated male animals, compared to females, have significantly lower percentage of fat, with the same dietary regime. They also state that the selection/breeding is a powerful instrument for reduction of fat content, and that adequate animal nutrition provides the ability to reduce fat content and fatty acid changes. Observing the share of certain tissues in the four basic parts of the carcass side (round, back, shoulder and ribs) in gilts and castrated males, *Kušec et al. (2006)* have found that the highest share of the muscle tissue is in the round, and that the highest share of fatty tissue is in the rib section, while the highest share of bone tissue is found in the back. By comparing the shares of the most important tissues of the main carcass parts with respect to the total quantity of individual tissues in the examined pigs, statistically significant differences were found between the sexes/genders only in the share of the round bone tissue in the total amount of bones *(Kušec et al., 2006)*. Distribution of fatty tissue, as well as the total amount of fat in the carcass, varies considerably between pigs of different breeds. For example, there is a clear difference in the content of intramuscular fat between various pig genotypes. It is generally higher in Duroc pigs than in Landrace or Large white pigs, although differences in the content of the subcutaneous and abdominal fat tissue between pigs of different genotypes can be small. Distribution of fatty tissue in the pig carcass can be changed relatively easily through selection/breeding. Variations in energy intake are the decisive

factor in the distribution of fatty tissue, as well as the total amount of fat in the pig carcass of certain genotype *(de Lange et al., 2003)*. In animals intended for meat production, the estimated heritability for the fat content is relatively high (between 0.3 and 0.6). This means that the selection/breeding is a powerful instrument for reducing fat content. An even better option for reducing fat content and changing fatty acid profile is adequate nutrition, especially in non-ruminant animals, since these animals absorb fatty acids in unchanged form *(Čepin and Žgur, 2003).* A complete statistically significant phenotypic correlation (r_P=0.975 **) between the share of muscle tissue in the round and the estimated lean meat content through dissection was reported in the research by *Senčić et al. (1991).*

Material and Methods

The study included 201 offspring (108 castrated males and 93 females) originating from sires of following breeds: Landrace (L), Large White (LW) and Pietrain (P). The studied animals were following genotype: Landrace (L; n = 48) genotype; two breed crosses with 50:50 share of parental breeds (LWxL, n=32; and PxL, n=23), two breed crosses with 75% of paternal breed [Lx(♀LWxL), n=35] and [LWx(♀LxWL) n=38] and three breed crosses [Px(♀LWxL) n=25]. Animals included in this study were born in four seasons: winter (n=38), spring (n=65), summer (n=40) and autumn (n=58). The separation of the round from the back (loin-lumbar) part and of the belly part was performed by a right angle cut in relation to the longitudinal axis between the last and the second to last, i.e. between the 5th and 6th lumbar vertebrae *(Walstra and Merkus, 1996).* After separating the round, total dissection was performed separating the skin and subcutaneous fat tissue, intermuscular fat, muscle tissue and bone tissue.

Figure 1. Separation and dissection of the round (Photo: Č. Radović)

The research was carried out on the farm, experimental slaughterhouse and in the laboratory of the Institute for Animal Husbandry, Zemun-Belgrade. Data was processed by applying the appropriate software package "LSMLMW and MIXMDL, PC-2 VERSION" *(Harvey, 1990)*, i.e. by using the procedure of the Least Squares Method in order to determine the significance ($P<0.05$) of systematic influences on the traits of meat quality. The model included: genotype, gender, birth season of offspring and carcass side weight (linear effect).

$$Y_{ijkl} = \mu + G_i + P_j + S_k + b_1(x_1 - \bar{x}_1) + \varepsilon_{ijkl}$$

Results and Discussion

Table 1 shows the LSMean values of the properties of the round. Animals of the genotype n. 6 [Px (LWxSL)], with the same weight of warm carcass side, showed higher values for RW and RMT compared to other genotypes. Fatteners of genotype 9 (75% LW) had the lowest mean values for weight of the round (8.931 kg) and muscle tissue (6.031 kg). Also animals born in the winter period had the lowest value for RW (9.220 kg), but these animals had the highest value for RMT (6.868 kg) compared to animals born in other periods. A very significant ($P<0.001$) effect of the weight of warm carcass sides on the weight and yield of individual tissues of the round was established by total dissection. The total weight of the round increased by 118 g/kg of the warm carcass side weight while the meat yield increased by 79 g per kilogram of warm carcass side. The genotype showed effect on ($P<0.001$) all investigated properties (Table 1). the season of birth on the weight of skin and subcutaneous fat tissue and on the weight of intermuscular fat of the round. The sex/gender significantly affected ($P <0.01$) the weight of skin and subcutaneous fat and the mass of the muscle tissue of the round but no significant effect was observed on other studied properties ($P>0.05$).

Table 1. The effect of genotype, sex/gender and season on the quality properties of the round in the offspring (LSMean ± S.E.)

Source of variation		RW[4)], kg	RST, kg	RINT, kg	RBT, kg	RMT, kg
μ ± S.E.		9.264±0.06	1.462±0.04	0.401±0.02	0.762±0.01	6.639±0.08
Genotype	1[1)]	9.003±0.06	1.297±0.04	0.344±0.02	0.766±0.01	6.596±0.08
	2	9.112±0.10	1.723±0.07	0.401±0.03	0.741±0.02	6.247±0.12
	5	9.290±0.14	1.269±0.10	0.334±0.04	0.767±0.02	6.920±0.18
	6	10.204±0.10	1.324±0.07	0.478±0.03	0.850±0.02	7.552±0.13
	8	9.046±0.18	1.424±0.13	0.411±0.05	0.722±0.03	6.490±0.23
	9	8.931±0.21	1.736±0.15	0.439±0.06	0.725±0.03	6.031±0.28
P[2)]		***	***	***	***	***
Sex	M[3)]	9.181±0.08	1.579±0.06	0.413±0.02	0.747±0.01	6.442±0.11
	F	9.347±0.08	1.345±0.06	0.390±0.02	0.776±0.01	6.836±0.11
P		NS	**	NS	NS	**
Season	Winter	9.220±0.17	1.219±0.12	0.376±0.04	0.756±0.03	6.868±0.22
	Spring	9.251±0.08	1.646±0.06	0.484±0.02	0.739±0.01	6.382±0.10
	Summer	9.294±0.09	1.574±0.06	0.383±0.02	0.775±0.01	6.563±0.11
	Autumn	9.292±0.07	1.408±0.05	0.363±0.02	0.777±0.01	6.745±0.10
P		NS	***	***	*	*
WCS (b)		0.118***	0.027***	0.006***	0.006***	0.079***

[1)]1-SL. 2-LWxSL. 5-PxSL. 6-Px(LWxSL). 8-SLx(LWxSL). 9-LWx(LWxSL); [2)]NS=P>0.05;*=P<0.05;**=P<0.01; ***=P<0.001; [3)]M- castrated males. F-females.WCS(b)- linear effect of the weight of warm carcass side; [4)] RW-weight of the round. RST- weight of the skin and subcutaneous fat tissue of the round.RINT- weight of the intermuscular fat tissue of the round.RBT- weight of the bone tissue of the round. RMT- weight of the muscle tissue of the round

With the average weight of the warm carcass side of 81.20 kg the highest average values for the weight of the round (RW; 10.204 kg) weight of the intermuscular fat tissue (RINT; 0.478 kg) bone tissue of the round (RBT; 0.850 kg) and muscle tissue of the round (RMT; 7.552 kg) were established in three-breed crosses of Px (LWxL) genotype compared to other genotypes. *Pulkrábek et al. (2006)* show in their study that the crosses had the share of muscles in the round of 84.93% (class R) up to 88.12% of the total weight of the round (class S) which is a significantly higher share than value of 71.66% obtained in the present study by observing the share of muscle tissue in the total weight of the round for all examined animals. A higher share of muscle tissue of the round in the total weight of the round was determined in the research by *Kosovac et al. (2008)* in relation to our research. In this research the share of muscular tissue of the round for following genotypes: the Swedish Landrace (SL) - 73.12%, for the three-breed combination with Duroc [Dx (SLxLW)] - 77.25% and for the three breed combination with Pietrain [Px (SLxLW)] – 76.46%. The influence of sex/gender on the total weight of the round was established by *Bahelka et al. (2007)*, which is contrary to our research. In the

mentioned study, and in concordance with the present research, greater weight of the round was recorded in the female animals than in castrated males. *Kušec et al., (2006)* have found that female animals have a higher share of total fat tissue and a higher share of subcutaneous fat tissue compared to not castrated males. The fact that muscular and fatty tissue depend on sex/gender is in concordance with our research (*Renaudeau et al., 2005; 2006; Renaudeau and Mourot, 2007; Serrano et al., 2007; Radović et al., 2008).*

Conclusion

With the average weight of the warm carcass side of 81.20 kg, the highest average values for the weight of the round (RW; 10.204 kg), weight of the intermuscular fat tissue (RINT; 0.478 kg), bone tissue of the round (RBT; 0.850 kg) and muscle tissue of the round (RMT; 7.552 kg) were established in three-breed crosses of Px (LWxL) genotype compared to other genotypes. The least skin and subcutaneous fatty tissue (RST. 1.269 kg) was recorded for PxL two-breed crosses. They had less skin and subcutaneous fatty tissue by 454 g and 467 grams, respectively, in relation to two breed crosses (LWxL) and LWx (♀LxLW). The research has shown that we have a genotype on a farm that gives more muscle tissue in the round by 1.521 kg [Px (♀LWxL): LWx (♀LWxL)] with the same weight of warm carcass side, which is a very large difference. With the same average weight of warm carcass side, female animals had a higher average weight of the round and a higher yield of muscle tissue compared to male castrated animals. The genotype showed effect on ($P<0.001$) all investigated properties (Table 1), the season of birth on the weight of skin and subcutaneous fat tissue and on the weight of intermuscular fat of the round. The sex/gender significantly affected ($P<0.01$) the weight of skin and subcutaneous fat and the mass of the muscle tissue of the round but no significant effect was observed on other studied properties ($P>0.05$). Based on the results presented, it is obvious that breeders should have terminal breeds in their herds, primarily Pietrain, in the production of fresh meat, as they have a significantly higher share of muscle tissue in the round, and therefore greater lean meat content, i.e. meatiness of the carcass sides.

Udeo tkiva u svinjskom butu u zavisnosti od genotipa, pola i godišnjeg doba

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Rezime

Istraživanje je obuhvatilo 201 potomka (108 kastriranih mužjaka i 93 ženke) očeva nerastova rase landras (L), jorkšir (LW) i pijetren (P). Ispitane životinje su bile sledećeg genotipa: landras (L; n = 48); dvorasni melezi sa 50:50 učešća roditeljskih rasa (LWxL, n=32; i PxL, n = 23), dvorasni melezi sa 75% roditeljske rase [Lx(♀LWxL), n=35] i [LWx(♀LxWL) n=38] i trorasni melezi [Px(♀LWxL) n=25]. Životinje uključene u ovo istraživanje rođene su tokom četiri godišnja doba: zima (n=38), proleće (n=65), leto (n=40) i jesen (n=58). Istraživanja su pokazala da su pri prosečnoj težini tople polutke od 81,20 kg, najveće prosečne vrednosti za masu buta (RW; 10,204 kg), masu međumišičnog masnog tkiva (RINT; 0,478 kg), koštanog tkiva (RBT; 0,850 kg) i mišićnog tkiva (RMT, 7,552 kg) u butu, utvrđeni kod trostranih meleza Px(LWxL) genotipa u poređenju s drugim genotipima. Najmanje kože i potkožnog masnog tkiva (RST; 1,269 kg) zabeleženo je kod dvorasnih meleza PxL. Imali su manje kože i potkožnog masnog tkiva za 454 g, odnosno 467 grama, u poređenju sa dvorasnim melezima (LWxL) i LWx (♀LxLW). Istraživanja su pokazala da na farmi postoji genotip koji daje više mišićnog tkiva u butu za 1.521 kg [Px (♀LWxL): LWx (♀LWxL)] sa istom masom tople polutke, što je vrlo velika razlika. Sa istom prosečnom masom tople polutke, ženska grla su imala veću prosečnu masu buta i prinos mišićnog tkiva u poređenju sa kastriranim muškim životinjama. Zabeležen je uticaj genotipa ($P<0,001$) na sve ispitivane osobine, takođe, zabeležen je uticaj sezone rođenja na kožu i potkožno masno tkivo i na masu intermuskularne masti buta. Uticaj pola je bio značajan ($P<0,01$) na masu kože i potkožnog masnog tkiva i na masu mišićnog tkiva buta, ali nije primećen značajan uticaj na druga ispitivana svojstva ($P>0,05$).

Ključne reči: tovljenici, masno tkivo, koštano tkivo, mišićno tkivo buta

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FATTY ACIDS IN FEED OF LAYING HENS ON THE PRODUCTION PARAMETERS AND THE RATIO OF OMEGA-6 AND OMEGA-3 FATTY ACIDS

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Original scientific paper

Abstract: Enriching table eggs with certain nutrients such as omega-3 fatty acids is an ongoing topic. Therefore, the aforementioned research was carried out with the aim of examining the possibility of feeding laying hens with ground flax seed, flax cake and flaxseed oil and their influence on the ratio of omega-6 and omega-3 fatty acids of table eggs, as well as on certain production parameters. The experiment was set up in a production facility with 192 consuming laying hens 27 weeks old. The laying hens were divided into 4 groups: control group; group fed with flax cake (10%) + flax oil (2%); a group fed with 5% ground flax and a group fed with 10% ground flax. Each group had 8 cages with 6 laying hens, a total of 48 laying hens per group. The production parameters presented in this paper are as follows: number of eggs per laying hen , egg weight and yolk weight. Egg quality indicators were determined at the end of the 5th and 10th week from the start of the experiment, namely: pH of egg white and yolk, polyunsaturated and saturated fatty acids ratio, as well as omega-3 and omega-3 fatty acids ratio. The results of the study showed that the inclusion of flax cake, flax oil and ground flaxseed had no negative effects on the shown production parameters and that there was a positive effect of these nutrients on the ratio of omega-6 and omega-3 fatty acids in table eggs.

Key words: laying hens, production parameters, fatty acids

Introduction

Eggs are an excellent source of readily soluble proteins for humans, polyunsaturated fatty acids, phospholipids and vitamins *(Škrtić et al., 2006)*. Nowadays, people are becoming more aware of the link between food and health and they are trying to maintain and improve their health through adequate nutrition. Food can only be considered functional if its basic nutritional impact has positive effects on human health *(Perić et al., 2011)*. Intensive production of table eggs has

focused all research on determining the impact of many factors on the productivity of light line hybrids of laying hens and the quality of eggs from the cage holding system *(Škrbić et al., 2011)*. Nutrition of laying hens with nutrients of plant or animal origin results with nutritious table eggs and therefore omega-3 fatty acids. Alpha-linoleic (ALA), eicosapentaenoic (EPA) and docosahexaenoic (DHA) fatty acids belong to the group of important omega-3 fatty acids for nutrition *(Coorey et al., 2014)*. Enrichment of table eggs with omega-3 fatty acids can be achieved if the diet of the laying hens is carried out with specially selected nutrients *(Meluzzi et al., 2000)*. With the exception of the shape index, a different way of laying and feeding of laying hens may affect most indicators of egg and shell quality *(Krawczyk, 2009)*. *Polawska et al. (2013)* reports the positive effects of food enriched with polyunsaturated fatty acids in human nutrition. Large quantities of these acids are found in fish and other seafood, but in many countries the consumption of seafood is low *(Carrillo-Domínguez et al., 2005)* so the way to increase the intake of omega-3 fatty acids is to produce functional foods enriched with them. From the natural sources of unsaturated fatty acids, flax is the plant that is among the most concentrated sources available for poultry nutrition *(Caston and Leeson, 1990)*. According to some reports, a flaxseed diet can have a negative impact on the production performance of laying hens. In the studies, *Jia et al. (2008)* reported reduced egg production, increased feed consumption, increased feed conversion and less weight of laying hens flax-fed at a concentration of 150 g / kg of mixture. The production of omega-3 enriched eggs with a more desirable omega-6 / omega-3 ratio compared to standard quality eggs is achieved through the use of omega-3 fatty acids, which is why the use of these fatty acids as a nutritional supplement has a nutritional, medicinal and economic advantage *(Šefer et al., 2011)*. Adding flax to the diet of laying hens at a concentration of 10% in eggs results in increased levels of ALA, EPA and DHA and decreased levels of arachidonic acid *(Hayat et al., 2009)*.

The aim of this experiment was to investigate the effect of the addition of ground flax seed and a combination of flax cake and flax oil on the production characteristics of consumable laying hens, the ratio of polyunsaturated and saturated fatty acids as well as the ratio of omega-6 and omega-3 fatty acids.

Materials and Methods

Experimental design and feeding of laying hens

The experiment was carried out on laying hens of a light line hybrid Lohmann Brown-Classic in a production facility. The laying hens are grouped into 4 groups (control group, group fed with flax cake at a concentration of 10% + flax oil added to feed at a concentration of 2%, group fed with 5% ground flax grain and group

fed with 10% ground flax grain). During the experiment, all laying hens consumed feed with 17.30% crude protein and 11.60 MJ / kg MEn (calculative). The tested nutrients (grounded flaxseed, flax cake and flax oil) were added to the representative samples in the controled feed, reducing the percentage of certain control feed nutrients to obtain isoprotein and isocaloric mixtures. Each group had 8 cages with 6 laying hens. The age of the laying hens at the start of the experiment was 27 weeks. Egg and yolk weight were measured on an electronic scale of 0.01 g accuracy, on a sample of 10 eggs per cage.

Chemical analysis of eggs

The fatty acid composition was determined at the end of the 5th and 10th week from the start of the experiment on samples of 10 eggs per cage, and an extraction method was used according to *Folch et al. (1957).* Fatty acid composition was determined using gas chromatography. A gas chromatograph used to determine (Perkin-elmer Varian 1400) was linked to a filled column (l = 3 m, d = 3.0 mm; stationary phase - GP 10% SPTM-2330) and a flame ionization detector.
The total omega-6 PUFAs are calculated as C18:2c + C20:3 ω-6 + C20:4 ω-6
The total omega-3 PUFA are calculated as C18:3 ω-3 + C20:5 ω-3 + C22:6 ω-3
The pH values of the yolk and egg white were determined at the end of the 5th and 10th weeks of the experiment by a portable pH meter (Testo 205, Lenzkirch, Germany) equipped with a stabbed reinforced combination electrode for direct determination of pH in food products and a temperature measuring sonde.

Statistical analysis

The results obtained in the study were processed by one-factor analysis of variance (software package IBM SPSS version 22). The significance level used in all tests was 1%, while Duncan's test was used in subsequent comparisons. The lowercase letters indicate statistically significant differences between the mean values of individual treatments over time. The averages do not differ significantly when not indicated by lowercase letters.

Results and Discussion

The results presented in Table 1 show that at the end of week 1 of the trial, the lowest carrying capacity (number of eggs / housed hen) was observed in the control group, but it did not differ significantly with respect to flax cake + oil and flax treatment 10%, while the highest carrying capacity was observed in the flax treatment of 5% and it was significantly higher compared to the control group, while it did not differ significantly from the treatments of flax cake + oil and flax 10%. In the follow-up period from week 2 to week 10, there was no statistically significant difference between the control group and the treatments observed. From

the above it can be seen that there was no negative effect of the addition of PUFA omega-3 in the feed on the production results of the treated groups compared to the control group. *Caston and Leeson (1990)* and *Jiang et al. (1991)* report that there was no negative effect of the addition of flaxseed to the feed of laying hens on egg production and weight, which is in accordance with the results of this work. *Scheideler and Froning (1996)* and *Aziza et al. (2013)* report increased egg production after the addition of flaxseed, fish oil or camelin meal. From the presented it can be seen that the results obtained in this paper are in accordance with the results of other papers.

Table 1. Egg production in experimental groups (egg number/ housed hen ± standard deviation)

Week of the experiment	Treatment				p-value
	Control	Flax cake+flax oil	Flax 5%	Flax 10%	
1.	6.52 ± 0.14a	6.60 ± 0.18ab	6.81 ± 0.06b	6.63 ± 0.20ab	0.06
2.	6.69 ± 0.19	6.50 ± 0.28	6.67 ± 0.20	6.54 ± 0.21	0.28
3.	6.65 ± 0.24	6.67 ± 0.27	6.79 ± 0.12	6.60 ± 0.24	0.39
4.	6.58 ± 0.24	6.52 ± 0.30	6.65 ± 0.21	6.58 ± 0.27	0.81
5.	6.62 ± 0.23	6.56 ± 0.30	6.67 ± 0.13	6.60 ± 0.24	0.84
6.	6.65 ± 0.24	6.58 ± 0.28	6.52 ± 0.27	6.62 ± 0.31	0.81
7.	6.44 ± 0.39	6.37 ± 0.21	6.42 ± 0.30	6.40 ± 0.09	0.97
8.	6.54 ± 0.31	6.44 ± 0.31	6.58 ± 0.28	6.54 ± 0.26	0.78
9.	6.42 ± 0.41	6.46 ± 0.12	6.54 ± 0.41	6.42 ± 0.47	0.90
10.	6.44 ± 0.41	6.42 ± 0.22	6.56 ± 0.22	6.44 ± 0.41	0.80

* a-b Average values with different letters in one line differ significantly at the level of 1%

Table 2 presents the results of the measured egg weight over the duration of the experiment.

Table 2. Egg weight in experimental groups ((g) ± standard deviation)

Week of the experiment	Treatment				p-value
	Control group	Flax cake+oil	Flax 5%	Flax 10%	
1.	60.61 ± 1.95	60.35 ± 1.28	60.83 ± 1.02	61.90 ± 2.13	0.28
2.	60.19 ± 1.76	60.39 ± 2.01	61.91 ± 2.15	61.95 ± 1.88	0.15
3.	60.24 ± 2.50	61.58 ± 2.37	61.99 ± 1.71	61.88 ± 3.11	0.48
4.	60.99 ± 1.62	61.58 ± 1.99	62.48 ± 1.61	62.15 ± 2.39	0.44
5.	61.29 ± 1.58	61.90 ± 1.71	62.74 ± 1.36	62.46 ± 2.57	0.43
6.	61.60 ± 1.50	61.90 ± 1.88	62.69 ± 1.48	62.65 ± 2.63	0.60
7.	61.63 ± 1.74	62.10 ± 1.96	62.91 ± 1.33	62.95 ± 2.61	0.47
8.	61.93 ± 1.75	62.00 ± 2.58	62.84 ± 1.49	63.28 ± 2.79	0.56
9.	61.79 ± 1.99	62.01 ± 2.91	62.95 ± 1.33	63.21 ± 2.74	0.55
10.	62.20 ± 1.99	62.11 ± 2.08	62.89 ± 1.39	63.46 ± 1.93	0.44

The results presented in Table 2 show that during the 10 weeks of the trial there was no statistically significant difference in egg weight between the control group and the observed treatments, while all groups reported an increase in weight. *Baucells et al. (2000); Novak and Scheideler (2001)* and *Ebeid (2011)* did not report the impact of PUFA sources on egg production and weight. *Sari et al. (2001)* reported that the addition of 15% flax seed reduced significantly egg weight ($p < 0.01$). *Scheideler and Froning (1996)* reported significantly lower egg weight of the group fed with 5% and 15% of added flaxseed concerning the control group and the group fed with fish oil. *Zotte et al. (2015)* found no effect of nutritional treatment on average egg weight.

Table 3 presents the results of the measured yolk weight during the experiment.

Table 3. Egg yolk weight in experimental groups ((g) ± standard deviation)

Week of the experiment	Treatment				p-value
	Control group	Flax cake+oil	Flax 5%	Flax 10%	
1.	14.59 ± 0.58	14.29 ± 0.29	14.13 ± 0.25	14.74 ± 0.60	0.05
2.	14.45 ± 0.70	14.50 ± 0.30	14.68 ± 0.42	14.50 ± 0.42	0.80
3.	14.60 ± 0.34	14.85 ± 0.39	14.86 ± 0.30	14.73 ± 0.65	0.61
4.	15.03 ± 0.40	14.80 ± 0.52	14.96 ± 0.32	14.85 ± 0.59	0.77
5.	15.18 ± 0.35	14.98 ± 0.28	15.14 ± 0.33	15.01 ± 0.38	0.59
6.	15.23 ± 0.45	15.04 ± 0.41	15.21 ± 0.33	15.18 ± 0.50	0.81
7.	15.30 ± 0.36	15.14 ± 0.48	15.23 ± 0.35	15.35 ± 0.47	0.76
8.	15.55 ± 0.47	15.19 ± 0.65	15.45 ± 0.44	15.38 ± 0.71	0.65
9.	15.68 ± 0.51	15.61 ± 0.82	15.49 ± 0.36	15.45 ± 0.72	0.88
10.	15.70 ± 0.46	15.69 ± 0.46	15.64 ± 0.49	15.61 ± 0.46	0.98

The results presented in Table 3 show that there was no statistically significant difference between the weight of the control group yolk and the observed treatments in week 1, and this trend persisted until the end of week 10 of the experiment. Also, the results show that in all treatments the weight of the yolk increased during the experiment. *Hayat et al. (2009)* reported that there was no effect on egg yolk weight when hens were fed flaxseed. *Sari et al. (2001)* report a decrease in yolk weight with an increase in flaxseed in feed. This decrease in yolk weight was not significant between the control group and the groups with added 5% and 10% of flaxseed, but was significant ($p < 0.01$) in the group with the added 15% of flaxseed. These results show that they are in accordance with the results of this paper where there was also no statistically significant deviation of the yolk weight between the control group and the groups with the added 5 and 10% of ground flax seed. *Scheideler and Froning (1996)*; *Novak and Scheideler (2001)* report a decrease in the proportion of yolk when fish oil or flax is present in feed. *Ebeid (2011)* used fish and flaxseed oil as a source of omega-3 PUFAs where he

did not find significant treatment effects on feed consumption, egg production, egg weight, or egg yolk height. In this paper, the weight of yolk in the treatment of flax cake + oil did not differ significantly concerning the weight of the yolk of the control group, as well as the other treatments included in the experiment. The yolk weight was not influenced by the level (0, 10 or 20%) of ground flax in feed *(Caston et al., 1994)*.
Table 4 presents the results of the analysis of certain chemical indicators of egg quality.

Table 4. Egg quality parameters in experimental groups (mean ± standard deviation)

Parameters	Week of the experiment	Treatment				p-value
		Control group	Flax cake + flax oil	Flax 5%	Flax 10%	
pH of white egg	5.	8.35±0.15[a]	8.46±0.15[ab]	8.61±0.08[b]	8.49±0.06[ab]	0.00
	10.	8.62±0.14	8.68±0.09	8.62±0.06	8.63±0.14	0.65
pH of yolk	5.	5.90±0.08	6.07±0.24	6.07±0.06	6.01±0.07	0.06
	10.	6.02±0.05	6.30±0.51	6.00±0.07	6.03±0.13	0.11
PUFA/SFA	5.	0.86±0.12[a]	1.08±0.07[bc]	0.94±0.12[ab]	1.11±0.11[c]	0.00
	10.	0.95±0.09[a]	1.19±0.11c	0.97±0.07[ab]	1.10±0.12[bc]	0.00
Ratio ∑omega-6/∑omega-3 fatty acids	5.	9.73±0.75[c]	1.48±0.17[a]	2.89±0.26[b]	1.90±0.27[a]	0.00
	10.	9.28±0.82[c]	1.57±0.17[a]	3.34±0.62[b]	1.63±0.19[a]	0.00

* a-c Average values with different letters in one line differ significantly at the level of 1%

The effect of the treatment on the pH value of the egg white at the end of week 5 of the experiment was significant (P <0.01). The results presented in Table 4 show that at the end of week 5, the lowest pH of the egg white was found in the control group, but it did not differ significantly with respect to flaxseed + oil and flax treatments of 10%, while compared to 5% with flax treatment was significantly lower. Flax treatment of 5% had the highest pH but it did not differ significantly from the treatments of flax cake + oil and flax 10%. At the end of the 10th week of the experiment, the effect of the treatment was not significant (p> 0.01) on the pH of the egg white and therefore there were no statistically significant differences between the groups. The effect of treatment on the yolk pH registered at the end of week 5 and 10 was not significant (p> 0.01), so there was no statistically significant difference between the observed groups.
The effect of treatment was significant (p <0.01) on the ratio of polyunsaturated (PUFA) and saturated fatty acids (SFA), showing an increase in agreement with the amount of PUFAs added through feed supported by other works *(Ferrier et al., 1995; Scheideler and Froning, 1996; Zotte et al., 2015).* Also, the results presented in Table 4 show that the effect of the treatment is significant (p <0.01) on the ratio of total omega-6 and omega-3 fatty acids, which decreases in line with the increase

in PUFA in feed, as reported by other authors *(Jiang et al., 1991; Scheideler and Froning, 1996; Sari et al., 2001; Zotte et al., 2015).*

Conclusion

From the results presented in this experiment it can be seen that by adding natural ground flax at a concentration of 5 and 10% as well as adding flax cake at a concentration of 10% together with flax oil at a concentration of 2% had no negative effects on the production characteristics of the laying hens in the experiment (egg production, egg weight, egg yolk weight). Also, the results obtained in this experiment show that the pH of the egg white showed a significant effect of PUFA enriched treatments at the end of week 5 of the trial, while at the end of week 10 there was no significant effect of treatments. However, the pH of the egg yolk did not show a significant effect of PUFA enriched treatments on its value at either the end of the 5th or the end of the 10th week of the experiment. Flax treatments of 10% and flax cake + oil had a significantly higher polyunsaturated / saturated fatty acid ratio at the end of week 5 and 10 compared to the control group.

The ratio of ∑omega-6 / ∑omega-3 fatty acids in both analyzes was significant statistically lower in the treatment of flax cake + oil and flax 10%, while in the treatment flax 5% was significantly higher concerning the previous two treatments but also significantly lower concerning the control group that had the statistically significant highest ratio.

From the above it can be concluded that PUFA enriched treatments in the experiment confirmed the possibility of enrichment of table eggs omega-3 with fatty acids with the specified nutrients, at the same time without undermining the production characteristics of consumable laying hens.

Uticaj korišćenja različitih izvora omega-3 masnih kiselina u hrani kokoši nosilja na proizvodne parametre i odnos omega-6 i omega-3 masnih kiselina

Jovo Perić, Milanka Drinić, Nenad Mićić

Rezime

Obogaćivanje konzumnih jaja određenim hranljivim materijama kao što su omega-3 masne kiseline je tema koja je stalno aktuelna. Sprovedeno je istraživanje

sa ciljem ispitavanja mogućnosti ishrane nosilja sa dodatkom mlevenog lanenog zrna, lanene pogače i lanenog ulja i njihovog uticaja na odnos omega-6 i omega-3 masnih kiselina u konzumnim jajima, kao i na određene proizvodne parametre. Eksperiment je postavljen u proizvodnom objektu sa 192 nosilje starosti 27 nedelja. Nosilje su bile podeljene u 4 grupe: kontrolna grupa; grupa hranjena sa lanenom pogačom (10%) + lanenim uljem (2%); grupa hranjena sa 5% mlevenog lanenog zrna i grupa hranjena sa 10% mlevenog zrna lana. Grupe su imale svaka po 8 kaveza u kojima je smešteno po 6 nosilja, ukupno 48 nosilja po grupi. Proizvodni parametri koji su prikazani u ovom radu su sledeći: broj jaja po useljenoj nosilji, težina jaja i težina žumanca. Pokazatelji kvaliteta jaja su određivani na kraju 5. i 10. nedelje ogleda i obuhvatili su: pH belanca i žumanca, odnos polinezasićenih i zasićenih masnih kiselina, kao i odnos omega-6 i omega-3 masnih kiselina. Rezultati istraživanja su pokazali da uključivanje lanene pogače, lanenog ulja i mlevenog lanenog zrna nije imalo negativnih efekata na prikazane proizvodne parametre, kao i da postoji pozitivan efekat navedenih hraniva na odnos omega-6 i omega-3 masnih kiselina u konzumnim jajima.

Ključne reči: kokoši nosilje, proizvodni parametri, masne kiseline

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THE ATTITUDES OF TABLE EGG CONSUMERS IN SERBIA ON THE WELFARE OF LAYING HENS

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Original scientific paper

Abstract: In order to examine the attitude of egg consumers about the poultry welfare and their willingness to spend more money to buy eggs produced in accordance with animal welfare principles, 529 consumers were surveyed in three regions of Serbia (Belgrade, region of Šumadija and Western Serbia and South and Eastern Serbia region). Through the survey questionnaire, consumers have stated how important the welfare of laying hens is to them and if they are willing to spend more money on eggs produced acording to principles of animal welfare. The answers of the surveyed consumers were analyzed by gender, age, education, number of children in the family and the environment in which they live. According to the results of the survey, it can be concluded that in Serbia, poultry welfare is moderately important to 28.17% of egg consumers and very important to 50.77% of consumers, while not at all or little to 21.13%, and that there are differences between individual regions. The willingness to pay more for eggs produced according to welfare principles was expressed by 78.53% of consumers, on average for all three regions. The analysis of data within the category of consumers for which the poultry welfare is very important, revealed that 54.15% are women and 44.02% are men, and that the welfare is more important for consumers with higher education (52.66%) compared to middle school (47.67%), also, for consumers in the 35-55 age group (55.60%) compared to younger and older respondents and those with three or more children in the family (52.94%) compared to families with fewer children. The survey results indicate that consumers in Serbia attribute more importance to the welfare of laying hens, and show their willingness to pay more for eggs produced in compliance with the welfare principles. In the coming period, the education focusing on the increase of consumer awareness of the importance of the welfare of laying hens and the connection with the quality of the product will be necessary.

Key words: welfare, laying hens, consumer, eggs, survey, Republic of Serbia

Introduction

In the European Union, the welfare of laying hens is defined by EU Directive 1999/74/EC, which bans the rearing of laying hens in conventional cages in all EU countries since 2012. However, implementation of this legislation has varied across countries, depending on the influence of manufacturers, retailers, consumers, law-makers, the media, and public opinion in general *(Appleby, 2003).* Research indicates that animal welfare is given greater importance in countries in northern Europe than in countries in the south and in the newly acceded EU member states (*European Commission, 2005*). According to *Frewer (2005),* the responsibility for introducing a system of livestock rearing that complies with the principles of welfare is shared by producers, lawmakers, various stakeholders in the food chain, as well as consumers.

Consumers have a very important role, on the one hand, through the expression of opinions and influence through public opinion, and on the other hand, by their decision to buy or not to buy certain products, they can significantly influence the market. Research indicates that European consumers generally have similar views on the welfare of farm animals and agree that welfare should be raised to a higher level, however, there are differences between countries due to varying degrees of knowledge about farm animals and different willingness to pay more money for the purchase of products obtained according to welfare principles (*European Commission, 2005; Martelli, 2009*). Some authors point to the need for better information availability and education of consumers about the importance of the welfare of farm animals (*Autio et al., 2017*), which would increase awareness of the importance of food production according to the animal welfare principles and the impact of animal welfare on the quality of animal products.

Attitudes about the welfare of laying hens have been the subject of much research, pointing to gender, education, and other socio-demographic differences among respondents *(Bejaei, 2009; Vecchio and Annunziata, 2011; Kehlbacher et al., 2012; Heng et al., 2013).* Part of the consumer attitude survey is the willingness to pay more money to purchase table eggs produced in cage-free production systems and other unconventional production systems *(Heng et al., 2013),* which is of great importance as the application of welfare standards results in increased production costs, and as stated by *Rodić et al. (2010)* eggs from cage-free systems can only be competitive provided that there is a willingness on the part of consumers to pay a higher price for eggs produced in this way.

In Serbia, the Animal Welfare Law (*Official Gazette of the RS, No. 41/2009)* came into force in 2009, and in 2010 a Rulebook on animal welfare

(Official Gazette of the RS 6/10, Official Gazette of the RS, No. 57/2014-27) was adopted on the breeding conditions that must be met by the breeders, forcing the producers of table eggs in Serbia to face the transition to cage-free farming of poultry. Some authors *(Pavlovski et al., 2011; Rakonjac, 2016)* point out the need and importance of paying attention to the implementation of new, alternative systems of rearing hens and poultry welfare, with most of the production of table eggs in Serbia being conventional. At the same time, there are few studies on consumer attitudes of Serbian consumers of eggs towards the welfare of laying hens *(Rodić et al., 2010; Stojanović, 2014).*

The aim of this paper is to determine the attitudes of consumers of table eggs in Serbia regarding the importance of the welfare of laying hens, as well as the willingness of consumers to pay more money for eggs produced with respect for animal welfare. At the same time, the paper aims to determine attitudes within a consumer group that considers animal welfare to be very important, based on gender, education, age, and number of children in the family.

Material and Methods

Survey questionnaire included 529 consumers on the territory of the Republic of Serbia, from three regions: Belgrade region (254 respondents), Šumadija and Western Serbia (161 respondents), and Southern and Eastern Serbia region (114 respondents), out of a total of five, according to the regional division of Serbia *(Statistical Office of the Republic Of Serbia, 2018).*

The structured survey questionnaire consisted of:

a) information about the respondents obtained by completing the offered answers for the following categories: gender (male, female), education (secondary school, higher education), place of residence (entering), age (less than 35, 36-55, over 55); children in the family (no children, one and two, three and more children).

b) closed-type questions on the nine-point Likert scale - where 1 was „not important to me at all“, and 9 was „very important to me“, applied to the question "How important is the welfare of laying hens when buying eggs?" and the question „How important is the farming/rearing system of laying hens when buying eggs?". The answers are grouped into 3 groups: 1 to 3 - not important/slightly important, 4 to 6 - medium and 7 to 9 - important/very important.

For the group of respondents who stated that the welfare of the laying hens was important/very important (7-9 on the Likert scale), the structure of consumers was determined for individual categories: gender, education, age and number of children in the family. The structure for individual categories was determined by placing in the ratio the number of consumers of a particular group who marked welfare with 7-9 (for example women) within individual category (in this case gender) to the total number of consumers in that group (total number of women).

c) the question with the answers offered was applied to the question "How much are you willing to pay more for eggs produced according to the principles of animal welfare?" and the answers offered are: "I'm not willing to pay more", "I'm willing to pay up to 30% more" and "I'm willing to pay more than 30%."

Standard analysis methods were used in the Microsoft Exel program to process the data.

Results and Discussion

The socio-demographic profile of the respondents is shown graphically (Figure 1). Analyzing the structure of the respondents, it was found that the survey included a large number of women (63.86%), compared to men, in terms of age, the majority of respondents ranged from 35 to 55 years (54.14%), and by education, those with secondary school education (64.96%).

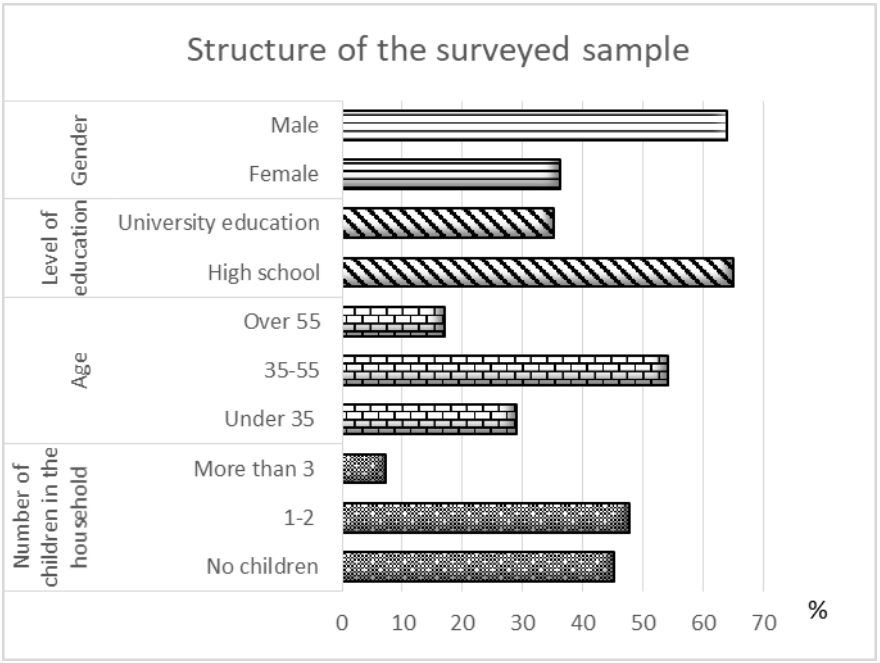

Figure 1. Structure of the surveyed sample

Table 1 shows the results related to the table egg consumers' attitude to poultry welfare in the various regions of the Republic of Serbia. By examining consumer attitudes in Serbia on the welfare of hens (Table 1), it can be concluded that the majority of respondents stated that the welfare was very important, average 50.77%

for all three surveyed regions, with the lowest values in Belgrade (45.84%), and the highest in the region of Šumadija and Western Serbia (60.31%). If the share of consumers for whom the welfare of laying hens is irrelevant is observed, it can be concluded that their share is the highest in the Belgrade (24.11%) region and the lowest in the region of Šumadija and Western Serbia (14.50%).

Table 1. The attitude of table egg consumers in Serbia towards the welfare of laying hens

Respondents' assessments of the welfare of laying hens	Not important / Slightly important	Medium important	Important/Very important
Answers to the question: How important is the welfare of the laying hens when purchasing eggs			
Region			
Belgrade (%)	24.11	30.04	45.85
Šumadija and Western Serbia (%)	14.50	25.19	60.31
Southern and Eastern Serbia (%)	22.12	27.43	50.44
Total (%)	21.13	28.17	50.77

The differences found in this research between regions can be related to studies that suggest differences in consumer attitudes towards welfare, depending on the area in which they live, that is, whether it is urban or rural *(Taylor and Signal, 2009).* The results obtained for Šumadija and Western Serbia region are in line with data provided by the *European Commission (2007)* according to which 62% of European consumers are ready to change their buying habits if they were produced according to the principles of farm animal welfare, while the average values for Serbia are lower. Also, according to a study by *Vecchio and Annunziata (2011)*, it was found that in a survey conducted in Italy, 62% of consumers showed a high level of interest in welfare, while 23% of consumers showed medium level and for 15% it was insignificant/irrelevent.

Table 2 gives an overview of the results related to the attitude of consumers of table eggs towards the hen farming system, that is, the production system of table eggs, by regions of Serbia.

Table 2. Consumers' attitudes in Serbia towards the hen farming system

Respondents' assessments of the farming/rearing system for laying hens	Not important / Slightly important	Medium important	Important/Very important
Answers to the question: How important is the farming/rearing system for laying hens when purchasing eggs			
Region			
Belgrade (%)	31.89	31.89	36.22
Šumadija and Western Serbia (%)	22.70	34.75	42.55
Southern and Eastern Serbia (%)	23.68	33.33	42.98
Total (%)	27.50	33.01	39.49

The analysis of data, reveals, on average, for all three regions, the production system is not important for 27.50% of consumers, while 39.49% considers it very important. Viewed by region, the Belgrade region has the highest share of consumers who find the production system not important (31.89%) and the lowest share of those who find it very important (36.22%).

Grunert et al. (2000) confirms that examining consumer attitudes about the farming/rearing system is one of the four most relevant criteria when considering consumers' attitudes to products: sensory properties, impact on human health, ease of preparation and production system for obtaining products of animal origin. According to *Tactacan et al. (2009),* one of the factors that led to the development of improved production systems is the concern for the welfare and the need for the hens to exhibit their natural behavior. Also, by analyzing data on the importance of welfare and the farming/rearing system (Tables 1 and 2), it can be concluded that respondents in Serbia attach greater importance to the welfare of farm animals (50.77 %) compared to the rearing system (39.49 %), which opens the question of whether consumers associate the rearing system with the welfare of poultry and whether they understand their conditionality. Authors examining consumer attitudes to welfare point to a lack of consumer knowledge about welfare standards and its relation to product quality *(Nocella, 2010).* Examining consumer attitudes towards animal welfare in Serbia, *Veljković et al. (2015)* conclude that in Serbia there is a low level of consumer information and education, while at the same time there is a great pressure to align production with international and domestic legislation in the production of food of animal origin in accordance with welfare requirements.

The results of the survey, obtained by the analysis within the consumer group which finds the welfare of laying hens to be important/very important, indicate the differences between the individual categories in terms of welfare attitudes (Table 3).

Table 3. Consumer structure within the group which finds the welfare of hens to be very important

Consumer structure within the group which finds the welfare of hens to be very important (7 to 9)				
Region	Belgrade (%)	Šumadija and Western Serbia (%)	Southern and Eastern Serbia (%)	**Total (%)**
Characteristic				
Gender				
Male	36.49	52.46	44.90	44.02
Female	50.00	63.75	53.85	54.15
Education				
Secondary school	43.00	60.00	48.78	47.67
Higher education	48.30	61.29	51.39	52.66
Age				
> 35	42.27	61.72	31.58	44.76
36-55	52.68	62.96	56.96	55.60
< 55	38.10	58.44	40.00	46.42
Children in the family				
No children	44.96	58.33	43.75	47.85
1 to 2 children	41.57	56.25	51.47	48.87
3 and more children	38.89	70.00	66.67	52.94

Of the female group surveyed, 54.15 % stated that the welfare of the hens was very important to them, which was higher than the male respondents (44.02 %). In the group of those who rate welfare as very important, more respondents were with higher education (52.66 %), ages 35 to 55 (55.60 %) and consumers with three or more children in the family (52.94 %).

Consumers' attitudes in Serbia are influenced by gender, education, age and number of children in the family as determined by *Stojanović et al. (2014),* who examined consumer attitudes in Serbia towards animal welfare, whose study also included laying hens. According to the results in Serbia, women expressed greater concern for the welfare of laying hens (54.15 %) than men, which is in agreement with *Mulder and Zomer (2017),* who associate this result with the greater role of women in the household and their caring for children and animals. In this study, consumers who had children attributed greater importance to welfare (52.94 %), compared to those without children (47.85 %). The findings that consumers with higher levels of education show greater concern for welfare have also been confirmed in research by *Maria, (2006), Vermeir and Verbeke, (2006)* and *Vanhonacher et al. (2007).* Viewed in a broader context, the results of the work can be related to a survey of consumers' attitudes about organic eggs in Serbia *(Tolimir et al., 2019),* which concluded that the highest share of buyers of organic eggs are females, consumers with higher education and consumers in the 36-55 age category, suggesting that the same consumer group in Serbia is interested in the poultry welfare.

Consumers' willingness to pay more money for eggs produced with respect for welfare requirements is shown in Table 4 by region.

Table 4. Consumers' willingness to pay more for eggs produced with respect to poultry welfare principles

Answers to the Question: Are you willing to pay more for eggs produced with respect for welfare principles			
Respondents' answers	**No (%)**	**Yes, up to 30%**	**30% and more**
Region			
Belgrade (%)	20.79	63.12	16.10
Šumadija and Western Serbia (%)	13.33	71.48	15.19
Southern and Eastern Serbia (%)	30.31	62.71	6.98
Total (%)	21.47	65.77	12.76

The share of consumers in Serbia who expressed a willingness to pay more for eggs produced in accordance with the welfare principles compared to conventional eggs was 78.53 %, ranging from 69.9 % in South and Eastern Serbia to 86.76 % in the region of Western Serbia and Šumadija. The results obtained are in line with data reported in *European Commission (2005)*, according to which the willingness of consumers in the EU to pay more for eggs produced according to welfare principles was 81% for a price higher by 5 to 10%. According to *Stojanović et al. (2014)* in Serbia, this share is 63 %, which is lower compared to the results of this research. *Nocella et al. (2010)* and *Heng (2013)* also indicate that there is a willingness on the part of consumers to pay more for food produced in accordance with animal welfare principles, however the *European Commission (2009)* states that while there is a willingness on the part of consumers to pay a higher price, they do not always put it into practice. Also, *Binnekamp and Ingenbleek (2006)* points to market barriers to products that are produced by welfare standards and, when it comes to consumers, cites a lack of complete consumer understanding of the concept of animal welfare and a lack of information on the quality of those products.

Conclusion

Survey results indicate that for 50.77 % of consumers of table eggs in Serbia, the poultry welfare is important/very important, although there are some differences between regions, i.e., in the Belgrade region, the majority of respondents found the welfare of hens to be not important/slightly important (24.11 %) and the least number of respondents who find it important and very important (45.85 %). Educating and informing consumers about the welfare of hens would

contribute to raising consumer awareness of the importance of welfare and the relation between welfare and product quality.

The welfare is of different importance for different categories of consumers, i.e., it is more important for females than men, for consumers with higher than secondary education, in the age group of 35-55 years compared to younger and older groups and for consumers in the family with three or more children compared to those with fewer children, and the results obtained could be significant in determining the target consumer of eggs produced according to hen welfare standards.

More than three quarters of consumers (78.53 %) in Serbia expressed their willingness to pay more for eggs produced in systems that are in compliance with hen welfare requirements, which may be a guideline for producers who are obliged to establish a hen rearing/farming system according to welfare standards, as well as other market players in Serbia.

The paper may be considered as preliminary research in this area and further research should be directed towards examining consumers' attitudes towards welfare, but with the aim of establishing their specific knowledge in the field of rearing method and how it influences the quality of the obtained products.

Stavovi potrošača konzumnih jaja u Srbiji o dobrobiti kokoši

Nataša Tolimir, Marijana Maslovarić, Zdenka Škrbić, Robert Radišić, Miloš Lukić, Borislav Rajković

Rezime

U cilju ispitivanja stavova potrošača konzumnih jaja o dobrobiti kokoši i njihove spremnosti da izdvoje više novčanih sredstava za kupovinu jaja proizvedenih poštujući principe dobrobiti anketirano je 529 potrošača u tri regiona Srbije (Beogradski region, region Šumadije i Zapadne Srbije i region Južne i Istočne Srbije). Kroz anketno ispitivanje potrošači su se izjasnili koliko im je važna dobrobit kokoši i kolika je njihova spremnost da za jaja proizvedena po principima dobrobiti izdvoje više sredstava. Odgovori anketiranih potrošača obrađeni su po polu, starosti, obrazovanju, broju dece u porodici i sredini u kojoj žive. Prema rezultatima anketnog ispitivanja može se konstatovati da u Srbiji potršačima jaja dobrobit kokoši osrednje važna za 28,17 % i veoma važna za 50.77 % potrošača, dok nije uopšte ili je malo važna za 21,13%, kao i da postoje razlike između pojedinih regiona. Spremnost da plate više za jaja proizvedena po principima dobrobiti iskazalo je 78, 53 % potrošača, prosečno za sva tri regiona. Analizom podataka unutar kategorije potrošača kojima je dobrobit kokoši veoma važna,

konstatovano je da je to kod pripadnica ženskog pola 54.15 %, a kod muškog pola (44.02 %), kao i da je dobrobit važnija potrošačima sa visokim obrazovanjem (52,66%) u odnosu na srednje (47,67 %), potrošačima u starosnoj grupi od 35 do 55 godina (55,60 %) u odnosu na mlađe i starije i onim koji u porodici imaju troje i više dece (52,94 %) u odnosu na porodice sa manjim brojem dece. Rezultati ispitivanja ukazuju da potrošači u Srbiji pridaju važnost dobrobit kokoši, kao i da iskazuju spremnost da plate više za jaja proizvedena uz poštovanje principa dobrobiti, ali je u narednom periodu potrebna njihova edukacija, koja bi doprinela povećanju svesnosti potrošača o značaju dobrobiti kokoši i povezanosti sa kvalitetom proizvoda.

Ključne reči: dobrobit, kokoši nosilje, potrošač, jaja, anketa, Republika Srbija

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ESTIMATION OF PHENOTYPIC VARIABILITY OF BODY MEASUREMENTS IN LIPIZZAN MARES

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Abstract: The aim of this work was a phenotypic description of the mare families of a Lipizzan horse breed from stud Vucijak. A total of 31 mares were measured, for every animal 28 measures were recorded. The mares are distributed by mare families in the following: Sana (3), Lipa (3), Bregava (3), Cremica (3), Ukrina (3), Visla (2), Neretva (3), Pliva (1), Drina (2), Sutjeska (2), Sitnica (1), Janja (2) and Sava. Simple analysis of variance was done to determine the difference in the morphological measures between mare families. Also, correlation between 28 measures was done. This study revealed phenotypic uniformity between mare families. Of the 28 measures recorded, a statistically significant difference was identified only for the length of cannon (front leg). The longest average length of the cannon (front leg) had at Sana (24.67 cm), and the shortest at Bregava (19.00 cm). The correlation ranged from slightly negative to highly positive with correlation coefficients from -0.465 to 0.779. Significant and highly significant correlation with height, length and depth was found in mare measures. The body shape of the mare families has a rectangular, which is in accordance with the Lipizzan horses from other stud in Europe. Also, the study revealed that mares from Vučijak are smaller than mares from other stud, which is in accordance with the breeding goals.

Key words: morphological measures, correlation, mare families, stud Vučijak

Introduction

Lipizzan horse is a unique horse breed in Europe and the world. They characterized long history of existence, strict and systemic selection, small population, precision of stud books, great morphological and genetic variability, etc. For this reason Lipizzan is cosmopolitan horse breed, is bred in many countries as well as on more

continents. In addition to state-owned stud, the Lipizzan is widely spread in many private breeders over the world, as a reflection of royalty and prestige.
State-owned stud Vučijak is the only Lipizzan stud in Bosnia and Herzegovina. It was founded in 1946. The horses-founders originated from Croatian state-owned stud Lipik and Đakovo, and from different private breeders in Croatia. According *Čačić and Čurik (2014)* stud Vučijak is the direct genetic successor of the "old" stud from Lipik (1938-1959) and indirect of stud farm Stančić (1919-1938). Subsequently, stallion and mares from Slovenia and Serbia were integrated into the stud population (*Rogić et al., 2018*). Establishing stud Vučijak, very soon Lipizzan horses spread to almost entire Bosnia, thanks to selective work at the stud Vučijak. The desirable characteristics of Lipizzan have led, not only to the quality of pure breeding program on stud Vučijak, but also to the great influence, as a meliorator, on the horse breeding in the Bosnia.
According to *Stipić (1980),* today's Lipizzan horse breeds was completely developed, with all the present sire lines and mare families, in the 18th and early 19th century, regardless of the fact that the beginnings of the creation of Lipizzan breed were dated back to the 16th century. Today, the Lipizzan horse breeds have had 8 sire lines and 66 mare families. Of the total mare families 17 is from Slovenia, 16 Croatia, 17 Hungary and 16 Romania (*LIF, 2019*). Of the 66 mare families on stud Vučijak are bred 15 (Table 1).
Zechner et al. (2001) was done characterization of the breed in their morphometric study of Lipizzan horses from eight different state-owned studs in seven countries. The aim of the paper was to present the mean and differences for these studs of 37 body measurements following a standard procedure developed by *Oulehla (1996)*. This work did not include all state-owned studs, as well as Vučijak, but served as a basis for similar research on the Lipizzan population at the national level. From this came the results of *Važić et al. (2016)* who worked on the morphometric characterization of Lipizann horse breed in the stud Vučijak, both stallion and mares. The authors concluded that Lipizzan horse from Vučijak have a smaller body frame then Lipizzan horse from other state-owned stud, wich is in coordinance with breeding goals of stud Vučijak (*Rogić et al. 2018*). Also, at present day, the morphometric measurements and body shape have important role in research not only for Lipizzan but also for other horse breeds (*Lopes et al., 2015; Martinon et al., 2014; Duml et al., 2018; Jenen et al., 2016; Fernandes et al., 2015; Ghezelsoflou et al., 2018*).
The beauty of the Lipizzan horse breed is present in their exterior, royalty walk and the possibility of their dress. In the presence of these traits a great influence certainly had mare families. So, the aim of this study was to get inide at the phenotypic variability of the mare families from stud Vučijak and to compare them among themselves.

Table 1. Mare families from stud Vučijak

No	*Name in Vučijak*	*Name in other studs*	*Faunding dam*	*Country*
1.	Drina	Traviata, Trofetta	Troffeta	Croatia
2.	Sutjeska	Siglavy, Toplica	Toplica	Hungary
3.	Sava	Pluto, Pakra	Pakra	Slovenia
4.	Sana	Argentina, Slava	Slava	Slovenia
5.	Bregava	Anemone	Anemone	Hungary
6.	Ukrina	Mima, Nana	Nana	Croatia
7.	Pliva	Alka	Liza	Croatia
8.	Neretva	Gidrana, Gaetana, Gaeta	Gaetena	Slovenia
9.	Lipa	Afrika, Batosta	Batosta	Slovenia
10.	Ilova	Reseda, Adica	Adica	-
11.	Sitnica	Almerina, Santa, Slovenia	Santa	Slovenia
12.	Visla	Virtuosa, Volga	Volga	-
13.	Jala	Zenta, Rendes, Krabbe	Zenta	-
14.	Kremica	Deflorata, Capriole, Canissa	Capriola	Slovenia
15.	Janja	Karolina	Darinka	Croatia

Material and Methods

Morphological measurement was taken at the stud Vučijak. A total of 31 mares were measured, and for every animal 28 measures were taken following procedure described in *Zechner et al. (2001)*. The mares were measured by the measuring stick and tape. For the measurement procedure, horses put on a hard floor, and only mares 4 years or older were measured. Mares are measured from the left side and all measures were recorded by the same person. The total 31 mares are distributed by mare families in the following: Sana (3), Lipa (3), Bregava (3), Cremica (3), Ukrina (3), Visla (2), Neretva (3), Pliva (1), Drina (2), Sutjeska (2), Sitnica (1), Janja (2) and Sava (2). Mares from Ilova and Jala were less than 4 years old, and were not measured.

According the fact that mare families Sana, Lipa, Bregava, Kremica, Ukrina and Neretva have 3 measured animals older then 4 years, which is rare in Lipizzan population on stud, simple analysis of variance was done to determine the difference in the morphological measures, whereby the F-test was calculated. The significance of the difference ($p<0.01$) was tested based on the Duncan test. Also, correlation between 28 measures for 31 mares was done with significant of level 0.01 and 0.05. The statistical program SPSS17 was used for data processing.

Table 2. Abbreviation of the 28 morphological measurements taken

HW - Height at withers (measuring stick)	CC - Circumference of chest
HB - Height of back	Ccc_1 - Circumference of cannon bone (metacarpal)
HR - Height of rump	Ccc_2 - Circumference of cannon bone (metatarsal)
BL - Body length	LH - Length of head
LF - Length of forequarters	WJ - Width of head (lower jaw)
LB - Length of barrel	Lua_1 - Length of upper arm 1
LR - Length of rearquarters	Lua_2 - Length of upper arm 2
DC - Depth of chest	LoF - Length of forearm
WC - Width of chest	LcF - Length of cannon (front leg)
WH - Width of hips	LpF - Length of pastern (front leg)
WT - Width of thurls	LoT - Length of thigh
LN - Length of neck	LsT - Length of second thigh
LS - Length of shoulder	LcH - Length of cannon (hind leg)
HWt - Height at withers (tape)	LcP - Length of pastern (hind leg)

Results and Discussion

Comparing the obtained results (table 3) with the results of *Važić et al. (2016)* it can be noticed that the mare families Sana, Ukrina and Neretva have higher height at withers than the average of the mares of stud Vučijak, while the Lipa, Bregava and Cremica have the smaller. The chest circumference at Cremica, Ukrina and Neretva are higher, while Sana, Lipa and Bregava smaller than average. The third basic measure in horses, circumference of cannone bone, was higher at Neretva, smaller at Sana, Lipa and Bregava, and the same at Cremica and Ukrina. According results we can concluded that mares from Vučijak were smaller then mares from Đakovo (*Rastija et al., 2004*) and other state-owned studs (*Zechner et al., 2001*). This conclusion are in accordance with the report of *Rogić et al. (2018)*.

Of 28 analyzed morphometric measures, only statistically significant differences were found between the mare families for the length of the cannon (front leg). The longest average length of the cannon (front leg) had at Sana (24.67 cm), and the shortest at Bregava (19.00 cm). The statistically significant smallest the length of the cannon (front leg) has Bregava and Cremica in regards to Sana, Ukrina, Neretva and Lipa.

The measuring results showed that mare families have a rectangular (height at wither: body length) format. The difference between body length and height at withers was the lowest at Sana (2.66 cm), and the highest at Cremica (7.33 cm). The obtained data correspond to results of *Zechnera et al. (2001)* conducted on the other state-owned stud of the Lipizzan horses. The authors showed that the mean value of height at withers were 3-8 cm smaller than values for body length.

Table 3. Differences in morphometric measures between six mare families from stud Vučijak

	Sana	*Lipa*	*Bregava*	*Cremica*	*Ukrina*	*Neretva*
HW	149.67	144.00	146.33	146.00	150.33	148.00
HB	144.00	141.00	142.67	143.33	147.00	141.67
HR	149.67	146.33	149.67	147.33	153.33	149.00
BL	152.33	149.67	151.00	153.33	153.33	153.67
LF	36.33	35.67	35.33	37.00	36.33	35.00
LB	74.67	68.33	72.33	70.67	75.00	73.33
LR	50.33	51.33	49.00	45.67	46.33	46.67
DC	69.00	67.67	66.00	64.67	69.00	66.33
WC	37.00	38.00	34.33	34.67	40.33	37.33
WH	52.00	51.33	49.00	53.33	52.33	50.67
WT	50.00	49.33	47.67	48.00	50.00	48.67
LN	66.33	67.33	67.67	65.33	68.33	64.33
LS	60.67	57.00	59.33	61.67	63.33	61.00
HWt	159.00	154.00	156.33	150.67	158.33	156.67
CC	167.33	174.67	174.00	180.67	176.33	175.67
Ccc_1	19.17	19.33	19.17	19.50	20.50	19.83
Ccc_2	22.17	22.00	22.00	22.00	22.17	21.50
LH	52.33	49.33	51.33	49.33	54.00	48.33
WJ	15.00	15.67	14.00	16.00	15.00	15.67
Lua_1	33.67	33.00	33.00	30.33	33.67	32.67
Lua_2	38.00	36.33	37.33	35.33	37.67	37.33
LoF	39.00	34.67	37.67	37.67	36.33	38.00
LcF	24.67^{B}	22.33^{B}	19.00^{A}	19.67^{A}	23.33^{B}	22.67^{B}
LpF	14.33	15.67	14.33	14.33	15.67	14.33
LoT	41.00	38.67	39.67	39.67	39.33	37.67
LsT	46.67	44.67	45.33	44.33	41.33	45.33
LcH	26.67	23.33	24.00	24.00	25.67	26.67
LcP	16.33	17.67	16.67	17.67	17.33	17.83

Correlation between some body measures plays important role in successful performance of breeding-selection work in horse breeding. If the correlation is positive, improvement on one property will result in other interrelated properties, improvement effecting selection success (*Rastija et al., 2003*). Correlation of 28 body measures of Lipizzan mares at Vučijak stud was presented in table 4.

The correlation ranged from slightly negative to highly positive with correlation coefficients from -0.465 (between length of pastern (front leg) and length of second thigh) to 0.779 (between height of wither and height of rump). The similar rang of correlation between mare families, from -0.304 to 0.826, found in Lipizzan mares from stud Đakovo (*Rastija at al., 2003*). Mostly positive and statistically highly significant or significant correlation showed measures made of tubular bones, such as the height: at withers (both, tape and stick), of back, of rump etc. Such correlation is logically because the development of animals in height at wither is accompanied by the development of other mentioned measures. In

addition, also statistically highly significant or significant correlation showed the measures made of plump bones, such as the length of: body, forequarters, barrel etc. Depth of chest showed the greatest correlation with other measures, with 15 measures showed significant and highly significant correlation. Significant and highly significant correlation with height, length and depth measures at Lipizzan mares from stud Đakovo also reported *Rastija et al. (2003)*. A negative correlation in this work was recorded only for one measure, length of second thigh. Width of head (lower jaw) does not show correlation with any measures. For other measures correlation significance was less pronounced.

Our results represent the first report of phenotypic description of mare families from stud Vučijak. The results of this study indicate that during the past century and breeding Lipizzan horses on stud Vučijak have led to a mares with smaller body shape, which was in accordance with the breeding goal on stud Vučijak (*Rogić et al., 2018*). Furthermore, new modern methods such as pedigree analysis, genetic analysis based on mtDNA, microsatellites as well as SNPs should be applied in future research of Lipizzan horses from stud Vučijak.

Table 4. Correlation coefficient among mare families body measures

	HB	*HR*	*BL*	*LF*	*LB*	*LR*	*DC*	*WC*	*WH*	*WT*	*LN*	*LS*	*HWt*	*CC*	Ccc_1	Ccc_2	*LH*	*WJ*	Lua_1	Lua_2	*LoF*	*LcF*	*LpF*	*LoT*	*Lst*	*LcH*	*LcP*
HW	+	+	n	n	n	n	+	n	n	n	n	*	+	n	n	n	n	n	*	*	n	+	n	+	n	n	n
HB	1	+	n	n	n	n	+	*	n	n	n	*	+	n	*	*	+	n	n	n	n	*	n	*	n	n	n
HR		1	n	n	*	n	+	n	n	n	n	n	+	n	*	*	*	n	+	+	n	*	n	+	n	n	n
BL			1	*	n	n	n	n	*	n	n	*	n	*	n	n	n	n	n	n	n	n	n	n	n	n	*
LF				1	+	n	n	n	n	n	n	*	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
LB					1	n	n	n	n	n	n	n	*	n	n	n	n	n	n	n	n	n	n	n	n	n	n
LR						1	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	*	n
DC							1	+	n	*	n	n	+	n	*	+	*	n	+	+	*	+	n	+	n	+	n
WC								1	n	+	n	n	n	n	+	+	*	n	n	*	n	n	n	*	*	n	n
WH									1	+	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
WT										1	n	n	*	n	n	*	n	n	n	*	n	*	n	*	n	n	n
LN											1	n	n	n	n	n	*	n	n	n	n	n	n	n	n	n	n
LS												1	n	*	n	n	n	n	n	n	n	n	n	n	n	n	n
HWt													1	n	*	+	*	n	+	+	n	*	n	*	n	*	n
CC														1	+	*	n	n	n	n	n	n	n	n	n	n	n
Ccc1															1	+	n	n	n	*	n	n	n	*	n	n	n
Ccc2																1	n	n	n	+	n	n	n	+	n	+	n
LH																	1	n	n	n	n	n	n	n	*	n	n
WJ																		1	n	n	n	n	n	n	n	n	n
Lua1																			1	+	n	+	n	*	n	n	n
Lua2																				1	n	n	n	n	n	+	n
LoF																					1	*	n	n	n	*	n
LcF																						1	n	n	n	*	n
LpF																							1	n	+	n	+
LoT																								1	n	n	n
LsT																									1	n	n
LcH																										1	n

+ Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, [n] Correlation is no significant

Conclusion

This study revealed phenotypic uniformity between mare families. Of the 28 measures recorded, a statistically significant difference was identified only for Length of cannon (front leg). Also, the study revealed that mares from Vučijak are smaller than mares from other stud. Significant and highly significant correlation with height, length and depth was found in mare measures.
The obtained results indicate a need for further study of Lipizzan horses from stud Vučijak, and its genetic and reproductive parameters, which would contribute to the improvement of selection and breeding program on stud Vučijak. The reported correlation can also be useful to improve breeding-selection work in Lipizzan breeding. Also, the obtained results are applicable in the field of conervation genetics, and protection of the genetic potential of Lipizzan horses, which is one of most valuable animal genetic resources from Bosnia and Herzegovina.

Procena fenotipske varijabilnosti telesnih mera kobila ergele Vučijak

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Rezime

Cilj rada bio je fenotipski opis rodova lipicanera ergele Vučijak. Ukupno je izmerena 31 kobila, a za svaku životinju je uzeto 28 telesnih mera. Merene kobile su pripadale sledećim rodovima: Sana (3), Lipa (3), Bregava (3), Cremica (3), Ukrina (3), Visla (2), Neretva (3), Pliva (1), Drina (2), Sutjeska (2), Sitnica (1), Janja (2) i Sava. Urađena je prosta analiza varijanse kako bi se utvrdila razlika u telesnim merama između rodova. Takođe je urađena korelacija između 28 telesnih mera. Ova studija otkrila je fenotipsku ujednačenost između rodova. Od 28 zabeleženih mera utvrđena je statistički značajna razlika samo za dužinu prednje cevanice. Najdužu prosečnu dužinu prednje cevanice imale su kobile roda Sana (24,67 cm), a najkraću kobile roda Bregava (19,00 cm). Koeficijent korelacije se kretao od neznatno negativnih do visoko pozitivnih, odnosno od -0,465 do 0,779. Utvrđena je značajna i visoko značajna povezanost sa merama visine, dužine i dubine kod kobila. Oblik tela kobila je pravougaoni, koji je u skladu sa lipicanerima iz drugih ergela u Evropi. Takođe, istraživanje je pokazalo da su kobile ergele Vučijak manje od kobila sa drugih ergela, što je u skladu s odgajivačkim ciljevima.

Ključne reči: morfometrijske mere, korelacije, rodovi, ergela Vučijak

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TREND ANALYSIS OF HARVESTED AREA, TOTAL PRODUCTION AND YIELD OF ALFALFA IN VOJVODINA

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Original scientific paper

Abstract: Vojvodina Province is a major alfalfa producer in Serbia with approximately 35.7% of total area and total production share of approximately 43.1%. In this paper, the data on area, production and yield of alfalfa observations from 1947 to 2018 and their variation and trends are analysed. The data indicate wide differences in the harvested area, total production and yield of alfalfa. The analysis of data indicates that harvested area and total production of alfalfa have declined over the past decades. Yield trend shows strong yield increase during 1950-1980 followed by periods of declined growth rates to 1990. After 1990s, dry matter yield has been stagnant. However, the increase, decrease and stagnation in yield are not strictly linear.

Key words: alfalfa, harvested area, total production, yield, trend analysis

Introduction

The increase in forage production has a fundamental role in improving availability, affordability and accessibility of feed. Alfalfa is perennial forage crop and it offers great potential for sustainable livestock production due to high production of green (80 t ha^{-1}) and dry matter biomass (20 t ha^{-1}) with high content (up to 23%) and digestibility of crude protein. It represent the main feed ingredient for the ruminants industry throughout the Serbia. Therefore, monitoring of the trends of cultivated area and yield of alfalfa is of great significance for understanding of feed availability and security. The estimate of crop production in the future must be based on historical yield trends to improve forecasting capability *(Grassini et al., 2013)*. In general, prognosis is that the yield of crop will decline in the future due to the reduction of arable land, water resources and increased warming trends and climate change *(Lobell et al., 2011)*. *Cassman (2001)*

considers that the yields of many crops are already high which will prevent further gains in the agricultural productivity. However, *Putnam et al. (2000)* believe that alfalfa will increase the area in the future due to the development of a dairy industry that requires the high quality of hay, like alfalfa hay, and due to the lack of profitable alternative crops. In addition, alfalfa has high genotypic and phenotypic plasticity which is why it is adapted to many ecoregions *(Baron and Belanger, 2007)*.

The purpose of our study is to analyse the harvested area, productivity and yield change of alfalfa in the Vojvodina region during the period 1947 to 2019. Also we forecast dry matter yield of alfalfa in the future.

Materials and Methods

Data for harvested area, production and yield of alfalfa were used from the Agriculture in Serbia, 1947-1996 (1998) and Statistical Yearbook of the Republic of Serbia from 1997 to 2019.

The mean harvested area, total production and yield of alfalfa, standard deviation and coefficient of variation are presented. The linear trend forecasting model was used for the interpretation of data on area, total production and yield of alfalfa ($Y = b0 + b1\ t$, were Y - area, total production and yield of alfalfa; t - trend which determines the tendency of time series data to increase or decrease over time and b0 and b1 - parameters of the model). Using the Pearson correlation, correlations among harvested area, total production and yield were investigated. The data were statistically processed by the linear regression method. The data was analysed in Statistical software 'Excel'.

Results and Discussion

The harvested area and total production of alfalfa in the Vojvodina province were increasing from 1947 to 1966, after which the decline occurred (Figures 1 and 2). Average harvested area and total production during investigated period were 63354.1 ha and 405714.4 t, respectively. Harvested area under cultivation of alfalfa ranged from 16049 ha (1948) to 106051 ha (1966), Table 1. Total production of alfalfa ranged from 77740 t (1948) to 776370 t (1966). Variation in harvested area (CV = 32.7%) and total production (CV = 42.8%) were high. The linear trend showed the decline of harvested area by 417.1 ha and of total production by 2483.4 t. In general, harvested area of alfalfa and other forage crops decreased due to the decline of cattle population in the Serbia. *Maletić and Popović (2016)* point out the negative trend of livestock production in Serbia from 2 to 3% per year. The livestock production makes 28.6% of the total agricultural production. This is not sufficient for sustainability of agriculture production because the lower limit is the share of 50%. A further decline of livestock

production is expected to decline harvested area of alfalfa and other fodder crops in favour other species (maize and wheat).

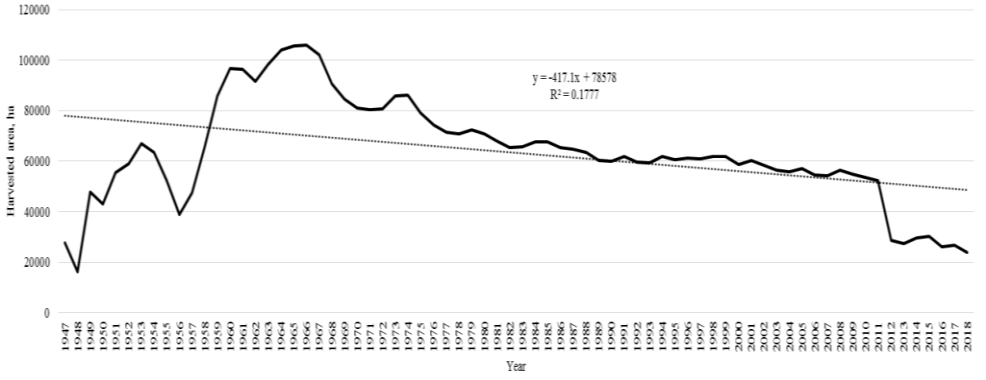

Figure1. Harvested area of alfalfa in Vojvodina during 1947- 2018

Figure 2. Total production of alfalfa in Vojvodina during 1947-2018

Table 1. Descriptive statistics for harvested area (ha), total production (t) and yield (t ha^{-1}) in Vojvodina from 1947 to 2018

Item	Mean	Minimum	Maximum	Coefficient of variation (CV), %
Harvested area	63354.1	16049	106051	32.7
Total production	405714.4	77740	776370	42.8
Yield	6.22	2.73	8.39	19.0

In regard to the yield trend, the long period 1947-2018 can be divided into three sub-periods: 1947 to 1981, the dry matter yield was increasing; 1982 to 1990 the dry matter yield was decreasing; and after 1990 the dry matter yield has been stagnating (Figure 3). However, the increase, decrease and stagnation in yield were not strictly linear.

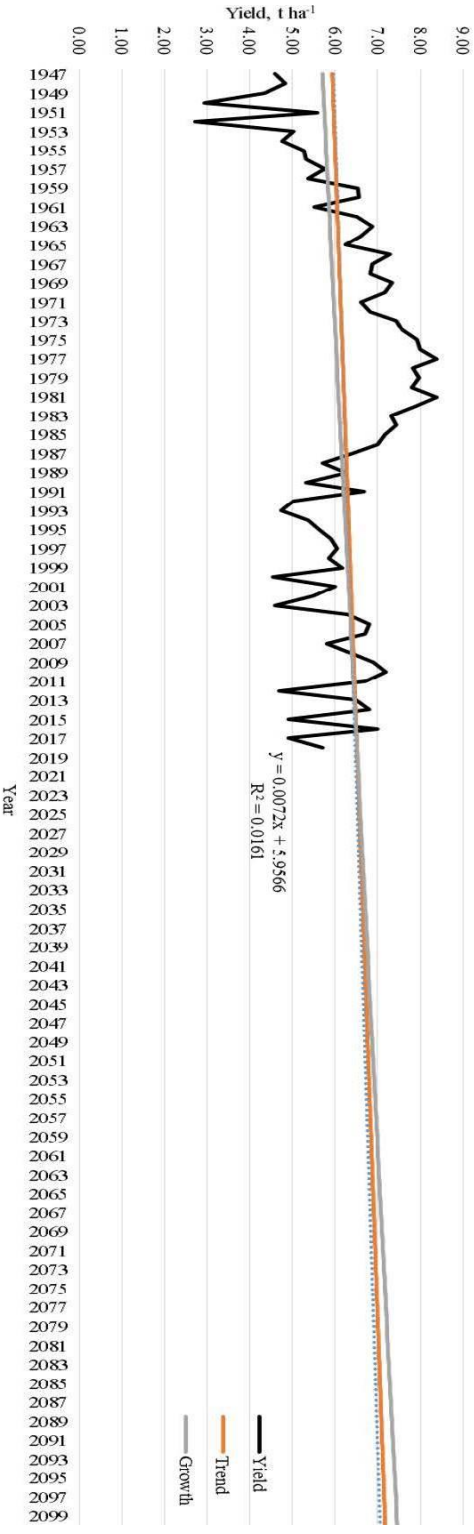

Figure 3. Total dry matter yield (t ha^{-1}) of alfalfa in Vojvodina during 1947-2018

The introduction of new technologies in alfalfa production during 1950-1980 (new cultivars, use of mineral fertilizers and pesticides, machinery improvements for planting and harvesting) contributed to the increase of yield. The investing in agricultural production from 1982 to 1990 did not lead to an increase of yield. In this period was a gradual decline in yield. Likewise, many studies have shown that the yield of important food crops has been declining even though investment in their production has increased *(Pardey et al., 2006; Alston et al., 2009)*. On the other hand, *Grassini et al. (2013)* emphasize the need to increase the level of investment in agricultural in order to maintain current yield of crop.

Average dry matter yield of alfalfa during the period from 1947 to 2018 was 6.22 t ha^{-1} and ranged from 2.73 t ha^{-1} (1952) to 8.39 t ha^{-1} (1977 and 1981). During the period 1947-2018 alfalfa yields improved at the rate of 7.2 kg ha^{-1} $year^{-1}$. The results show that the yield in 2100 will be 7.18 t ha^{-1}. This increasing trend provides the opportunity for livestock sector development in future because the plant production represents the basis for the development of livestock production. Of course, increasing number of livestock and improving the breed structure is essential for sustainability of agricultural production.

The coefficient of variation of dry matter yield (19.1%) indicates high variability of yield. The large variations in alfalfa yield can be attributed to weather conditions. The modern cultivars of alfalfa have high genetic potential for yield. However, their yield potential was not used because of the dependance on rainfall. *Ćupina et al. (2014)* report that the genetic potential of alfalfa is drastically reduced due to unfavourable climatic conditions (low rainfall and high temperature) in the summer months when second and third cuts are absent. Therefore, the water management improvement would be a significant contributor to the increase of yields. Researches of *Klocke et al. (2013)* and *Li et al. (2015)* show that yield of alfalfa significantly increases when the irrigation amount increases. Unfortunately, in Serbia irrigation of alfalfa is not represented. Accordingly, alfalfa production totally depends upon the amount and distribution of rainfall.

Essentially, in an effort to increase alfalfa yield, two major factors are at our disposal: a cultivar with the genetic potential and agricultural practices, as a technology solution that allows different degrees of utilization of the genetic potential of the cultivar. In the long run, the trend shows a lower increase in alfalfa yields in the future. However, this requires development and implementation of new genotypes that are resistant on abiotic and biotic factors and adapted to specific conditions of locations *(Gover et al., 2014)*. Generally, genotypes grown in Serbia are characterized by winter hardiness and resistance to disease and insects. Timely implementation of all necessary agro-technical measures (sowing, seed preparation, protecting from pests and diseases, time of cutting) with favourable rainfall and temperature will contribute a safe and optimal yield, that is, better utilization of the genetic yield potentials of alfalfa genotypes.

The limiting factors for alfalfa production in the future will be water quality and availability and cost of production. On the other hand, the forage yield and nutritional quality for animal feeding, must increase. Alfalfa will continue to represent a significant segment in the world agricultural economy due to its prominence in dairy rations.

The reducing harvested area and stagnation, and even the reduction of dry matter yield per unit of area indicate of decreasing total production of alfalfa the last decade. The harvested area has a strong positive correlation with total production and moderate positive correlation with yield (Table 2). The total production has a strong positive correlation with yield. It implies that harvested area significantly ensures total production, and yield per unit area ensures total production.

Table 2. Correlation coefficients among harvested area, total production and yield of alfalfa

Item	Total production	Yield
Harvested area	0.92**	0.45*
Total production		0.74**

To summarize, the assessment harvested area, total production and dry matter yield of alfalfa provides strategic planning to develop livestock production. However, the check the reliability of forecasted outcomes should include the series of mathematical, econometric or statistical models.

Conclusion

Since alfalfa yields are variable, it can significantly could affect food safety. In conclusion, this information may provide useful indications regarding the prediction of alfalfa yield in Vojvodina with emphasis on limiting factors for high and stable production. Making timely forecast of alfalfa production in Vojvodina can be very important step for enhancing production of cattle, sheep and goat farming. Unfortunately, in the future the prognosis is that the productions of alfalfa has a weak upward trend, such as livestock production.

Trend analize žetvenih površina, proizvodnje i prinosa lucerke u Vojvodini

Violeta Mandić, Zorica Bijelić, Vesna Krnjaja, Maja Petričević, Aleksandar Simić, Ivan Krga

Rezime

Vojvodina je glavni proizvođač lucerke u Srbiji sa oko 35,7% ukupne površine i udelom proizvodnje od 43,1%. U radu analiziramo podatke o površini, ukupnoj proizvodnji i prinosu lucerke u periodu od 1947. do 2018. godine i njihovim varijacijama i trendovima. Takođe, procenjujemo da li je rast prinosa zastao tokom poslednjih godina. Podaci ukazuju na velike razlike u žetvenoj površini, ukupnoj proizvodnji i prinosu lucerke. Analiza podataka pokazuje da su žetvene površine i ukupna proizvodnja lucerke opali tokom poslednjih decenija. Trend prinosa pokazuje snažan porast prinosa od 1950. do 1980. godine, a zatim sledi period opadanja prinosa do 1990. godine. Nakon 1990. godine, prinos suve materije lucerke stagnira. Međutim, porast, smanjenje i stagnacija u prinosu nisu strogo linearni.

Ključne reči: lucerka, žetvena površina, proizvodnja, prinos, analiza trenda

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BIOLOGICAL FEATURES AND PRODUCTIVITY OF ALPACA

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Short communication

Abstract: Alpaca domestication took place more than 6000 years ago. The Indians of Peru discerned the potential in these animals, tamed them and began to breed. In the past, alpacas were called the "Inca gold": they could provide people with all the necessary resources for living. People dressed in skins, ate meat, spun wool and made clothes, and used manure as fuel. An increase in the number of livestock on the Russian Alpaca and Capri farms favorably affects the further distribution of alpaca as a species in Russia. The possibility of recognition of alpaca as an agricultural animal will be the sale of wool, its processing, as well as the rejection of imported raw materials.

Key words: alpaca, Andean sheep, eco-farm, wool, tylopoda, camelid.

Introduction

Alpaca or Andean sheep lives on the highlands of South America in the Andes, at an altitude of 3500 - 5000 meters in Ecuador, Southern Peru, Northern Chile and Western Bolivia *(Wheeler, 2016).*

Alpaca belongs to the cloven-hoofed detachment, the corpus callosum, the camelid family, the vicuna family, and the alpaca species. Earlier, alpaca was mistakenly assigned to the genus of llamas, later, scientists make changes to the taxonomy. This is due to the fact that the ancestors of the alpaca are vicunas, and lamas are guanacos. Crossbreeding these animals between themselves gives the prolific offspring of variso (or vari), which is characterized by a flexible character, but significantly low wool quality. All four families have 37 chromosomes and can freely interbreed. Animals lead a daily life, these are herd animals, their life expectancy is up to 25 years, production is up to 7 years *(Lalonde, 2014).*

Reproduction of alpaca has its own characteristics, and does not have a clear seasonality when animals are raised on a farm. Unlike sheep and cattle, alpaca is always in the follicular phase, therefore, until the mating occurs, the

female is in a constant state of estrus. Ovulation occurs 26 hours after stimulation. Artificial insemination is difficult due to the laying position of the female during mating. Abroad, embryo implantation is practiced. In natural mating, high mortality of the embryos is observed, only 50% of them remain viable after 30 days of embryonic development. The female's pregnancy lasts 11 months, one offspring weighing 8 kg is born, the lactation period lasts 6 months. Maturity in females occurs by 18 months, in males by 2.5 years *(Kochish et al., 2008; Fanny, 2016).*

The alpaca constitution is dense, lean, with a slight bias towards flexibility. She is associated with her lifestyle, as the animal must be smart and light, so that it can easily move up the hills and run away from natural enemies. The respiratory type is characterized by increased metabolism. Animals have elongated limbs, a long neck and trunk, straight thin lines. Intensive oxidative processes inhibit fat deposition in alpaca. In the physique, the free proximal femur is noticeable *(Wheeler, 2016).*

The callosities have no hooves, and on the two-fingered limbs there are only blunt, curved claws, they must be trimmed to avoid curvature and weakening of the joints of the legs. They do not rely on the ends of the fingers, like ungulates, but on the totality of the phalanges of the fingers. The lower surface of the foot is a pair of corpus callosum. Unlike artiodactyls, alpaca does not trample grass, which favorably affects pastures *(Clive, 2017).* Alpaca has started breeding in Russia and is becoming a very popular domestic animal (*Alpakainfo website*).The aim of this paper is to present the basic breeding and morphological characteristics of the Alpaca in Russia.

Materials and Methods

Alpaca measurements in table 1 were obtained by measuring the articles of animals at the Russian Alpaca eco-farm in Moscow Region, Dmitrovsky District, and the village of Pokhodkino, where the alpaca population is 11 males and 9 females, as well as 3 llamas The study was conducted in September 2018 by a random sampling of sexually mature females and male males born in 2009-2011. The tools that were used are a measuring stick, tape, compass. All animals were kept and feed in the same breeding conditions according to the technology used Data processing was performed by descriptive statistical analysis.

Results and Discussion

Biological features

The physical appearance of the alpaca phonotypes is shown in Figures 1 and 2.

Callosities - ruminants, the rumen and abomasum have a special structure and are very different from those of other ruminants; the ruminant stomach is missing. The cecum is short. Half of the lower jaw fused. Able to eat sparse vegetation, shrubs, spines. The animal captures grass, stems and branches with the help of incisors pressing them to the tooth pillow (chewing plate) on the upper jaw. The incisors are located on the lower jaw in an amount of 6 pieces (3 on each side), are not sharpened in enamel and grow throughout life. If the alpaca has the correct bite, then they grind from friction against the tooth pillow when closing, if the teeth protrude significantly forward, then natural abrasion does not occur, it is necessary to cut the incisors. There are "fighting" fangs, most noticeable in males. There are no horns *(Summerton, 2017).*

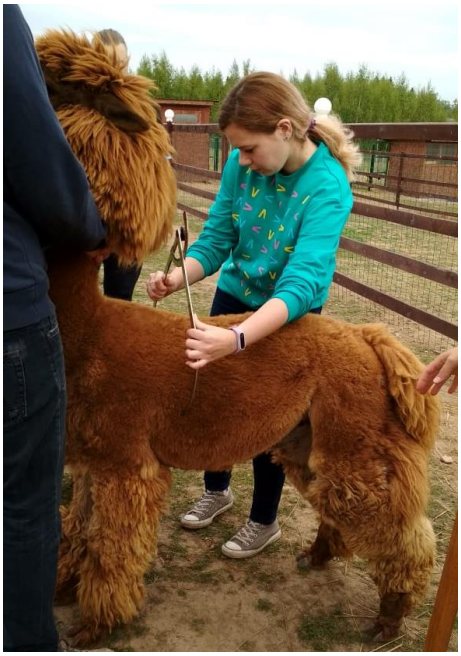

Figure 1. Taking Alpaca Measurements of Russian Alpacas

Figure 2. Animals on the eco-farm

Alpacas and llamas have certain behavioral characteristics that distinguish them from other domestic animals. They defecate and urinate in limited areas, even if they are given freedom of movement to other places. This habit is very important in the fight against internal parasites *(Kochish et al., 2008).*

The respiratory system is tuned to high-altitude discharged air, red blood cells are elliptical and their growth rate is increased, the bone marrow works intensively, the blood supplies the body with oxygen enough, as a result of which hypoxia does not occur. Camelids are model animals in many pharmaceutical companies, which are developing to create drugs based on their antibodies. One of the organizations that participates in these studies is the Capri farm in the Kaluga Region, which provides alpaca blood to scientific laboratories. Farm animals "Russian Alpacas" also take part in research *(website village, 2015, Summerton, 2017).*

The use of alpacas as pack animals for mountaineering is very developed, they can carry up to 50 kg over short distances, after a short rest they are ready to work again, that is why they are inferior to their relatives llama and camel. Alpaca is the undisputed leader in the production of fine wool *(Wheeler, 2016).*

Animals give valuable wool of quality 80 while merino wool of quality 60. Two alpaca breeds are known - huakaya and suri. In huakaya, crimped wool with a fineness of 20-32 μm is similar to the coat of sheep of the Corridel breed. Suri has a longer and thinner hair of 19-25 microns, pigtails hang down to the ground, having a corkscrew shape resembling the hair of a Lincoln sheep. The number of suri is small, it makes up only 5 percent of the whole species - 3 million, this is about 120 thousand individuals, so their wool is twice as valuable. Haircuts are carried out once a year in May and June. Alpaca wool having a fineness of more than 35 μm is classified as llama wool.

The most valuable fleece is obtained after the first haircut called "Baby Alpaca". The fiber fineness changes with age, which ranges from 1 μm to 5 μm per year. The length of the fur on the sides is 15-20 cm. The hairline is similar to the coat of sheep, but has a number of features. Fibers are stronger than Angora wool, finer than cashmere, smoother than silk fibers, softer than cotton, warmer than goose down, it is believed to be warmer than sheep's wool and more hygroscopic *(Bengtsson, 2016, Website village, 2015).*

There are 22 natural shades, from white, traditionally beige or silver to brown and black, white is valued above all. The fiber is not subject to rolling during wear. The grease is absent in the composition of the rune *(Bengtsson, 2016).*

Production features

The results of the body measures of the animals are shown in Table 1. Alpaca has no external signs of sexual dimorphism, but after analyzing the table,

we can conclude that the group of males is superior to the group of females in the following parameters: height at the withers, height in the sacrum, chest depth, chest circumference.

Females lead in terms of breast width and OBL. Ilium width and metacarpus have the same parameters for both sexes. Also, if we consider animals individually, it is noteworthy that the males Isaac and Rocky are physically close to females in most parameters, and Charlie leads in almost all respects.

Table 1. Results of Alpaca body measurements

Traits	Sex							
	Male				Female			
	Isaak	Charly	Rokki	$\bar{x}$	Silvia	Matilda	Ella	$\bar{x}$
Height at the withers,cm	93	94	93	93	89	90	89	90
height in the sacrum, cm	94	95	94	94	90	92	91	91
Metacarpus, cm	14	13	12	13	13	13	12	13
Oblique body length (OBL), cm	79	79	76	78	80	80	79	80
Ilium Width, cm	22	25	22	23	22	23	23	23
Chest width, cm	25	30	28	28	28	30	29	29
Chest depth, cm	35	40	40	38	35	35	36	35
Chest circumference,cm	107	120	116	114	111	115	110	113

From the table shown, we can see that male throats in most cases have higher values of measured performance. it is also noted that female animals also had an advantage in certain traits. Phenotype variability is also seen, which provides the possibility of selection in the population during the next rearing period.

Table 2 shows data on live weight and shearing of animal hair from the Russian Alpaca farm.

Table 2. Live weight and wool cut

Sex	Males				Females			
Names	Isaak	Charly	Rokki	$\bar{x}$	Silvia	Matilda	Ella	$\bar{x}$
Body weight, kg	70.5	83.3	76.3	76.7	55.8	68.2	61.2	62
Wool cut, kg	4.1	5.2	4.8	4.7	2.8	3.5	3.8	3.4

The average mass of males exceeds females by 15 kg, which indicates that they are larger. Repeatedly observed sexual dimorphism. There is a noticeable dynamics of an increase in hair cut depending on the live weight of alpaca, this feature is not dependent on the sex of the animal. According to the table, it can be understood that the animal with the smallest live weight has the minimum shear in

the group, and the alpaca with the highest weight indicator leads in the amount of kg of sheared wool.

Conclusion

Alpaca in Russia is an exotic non-common species. Most of them are contact animals living on eco farms.

An increase in the number of livestock on the Russian Alpaca and Capri farms favorably affects the further distribution of alpaca as a species in Russia. The possibility of recognition of alpaca as an agricultural animal will be the sale of wool, its processing, as well as the rejection of imported imported raw materials.

Produktivnost i biološke karakteristike alpake

Arina Igorevna Ponomareva, Irina Nikolajevna Sicheva

Rezime

Pripitomljavanje Alpake desilo se pre više od 6000 godina. Indijanci Perua opazili su potencijal ovih životinja, pripitomili ih i počeli da ih gaje i razmnožavaju. U prošlosti su se alpake zvale „Inka zlato“: One su mogle pružiti ljudima sve potrebne resurse za život. Ljudi su oblačili kože, jeli su meso, preli vunu i pravili odeću i koristili stajski gnoj kao gorivo. Povećanje broja stoke na ruskim farmama alpake i kapri povoljno utiče na dalju distribuciju alpake kao vrste u Rusiji. Mogućnost prepoznavanja alpake kao farmske/poljoprivredne životinje je kroz prodaju vune, njena prerada, kao i odbacivanje uvoznih sirovina.

Ključne reči: alpaka, andske ovce, eko-farma, vuna, tilopoda, kamelid.

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