ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 65 13 Number 1, 2017
https://doi.org/10.11118/actaun201765010111

GROWTH CURVES IN LAMBS OF VARIOUS GENOTYPES CREATED ON THE BASIS OF IMPROVED VALACHIAN AND TSIGAI BREEDS

Pavol Makovický[1], Milan Margetín[2,3], Melinda Nagy[1], Peter Makovický[4]

[1]Department of Biology, Faculty of Education, J. Selye University, Bratislavská cesta 3322, 94501 Komárno, Slovak Republic
[2]Department of Animal Production, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 94976 Nitra, Slovak Republic
[3]National Agricultural and Food Centre, Research Institute for Animal Production Nitra, Hlohovecká 2, 951 41 Lužianky, Slovak Republic
[4]Laboratory of Veterinary Histopathology in Komárno, Komárno, Slovak Republic

Abstract

MAKOVICKÝ PAVOL, MARGETÍN MILAN, NAGY MELINDA, MAKOVICKÝ PETER. 2017. Growth Curves in Lambs of Various Genotypes Created on the Basis of Improved Valachian and Tsigai Breeds. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 65(1): 0111–0118.

Changes in live weight or dimension for a period of time are explained by growth curves. The objective of this work was to evaluate the growth curves in lambs of 6 (1st experimental group) and/or 5 genotypes (2nd group) created on the basis of Improved Valachian (IV) and Tsigai (T) breed. All lambs (n = 209 and 205) were kept from birth to 9 months of age in identical conditions. Lambs of both experimental groups were weighed at birth and then every week until weaning (8 weightings totally). After weaning only breeding ewe and ram lambs were weighed (6 times totally). The growth of lambs created on the basis of IV a T breeds showed linear course till weaning expressed in regression equation $y = 0.2659x + 5.352$ and $y = 0.2404x + 4.7364$ respectively ($R^2 = 0.985$ and/or 0.9954; x – day of raising). Weight differences between genotypes grew after weaning. The average weight of lambs at the age of 150 days was 40.15 kg in the 1st group and 38.31 kg in the 2nd group respectively. The lowest weight was in purebred IV (38.13 kg) a T lambs (34.98 kg) and the highest in the purebred Lacaune lambs (43.82 kg and/or 44.29 kg). Differences between genotypes were statistically highly significant ($P < 0.001$). The differences among genotypes were even more marked at the age of 9 months. Growth of lambs from birth to the age of 9 months can be expressed in the best way by means of polynomic equation ($R^2 = 0.99$ in both experimental groups).

Keywords: lamb, growth curves, breed

INTRODUCTION

Growth is described as a change in volume, size or shape of an organism over time. It is a very important characteristic of living organisms. Changes in live weight of lambs or dimension for a period of time are explained by the growth curves. Analysis of animal growth performance through the life span is helpful to establish appropriate feeding strategies and the best age for slaughtering. Studies focusing on growth curves have increased in recent years due to the development of new computational methods for faster and more accurate analyses as well as the availability of new models. Growth curve models provide a set of parameters that describe growth pattern and estimate the expected weight of animals at certain ages. In addition, the parameters obtained from growth functions are highly heritable and have been used in selection studies (Ulutas *et al.*, 2010; Daskiran *et al.*, 2010; Koncagul *et al.*, 2013; Sen *et al.*, 2013; Aktas *et al.*, 2014; Bahreini Behzadi *et al.*, 2014; Kopuzlu *et al.*, 2014; Ghavi Hossein-Zadeh, 2015). Farmers are interested in collecting knowledge of genotypic and phenotypic relationships among weights of lambs during all phases of growth. Fitting growth curves to growth functions is an effective method for assessing different management factors, or for breeding purposes. Growth intensity of lambs before weaning and after weaning significantly affects the economics of farming (Petr *et al.*, 2009; Pajor *et al.*, 2008; 2009a; 2010; Wolfová *et al.*, 2009; Komprda *et al.*, 2012; Svitáková *et al.*, 2014; Koutná *et al.*, 2016). The growth is affected by many factors where the most important are the breed, nutrition, sex, litter size, management, biotic stress, health and age of mothers (Kuchtík and Horák, 2007; Dobeš *et al.*, 2007; Hošek *et al.*, 2008; Pajor *et al.*, 2007; 2009b; Kuchtík *et al.*, 2010; 2011; Zapletal *et al.*, 2010; Štolc *et al.*, 2011; Ptáček *et al.*, 2013; 2015; Lupi *et al.*, 2015; Waheed *et al.*, 2015; Aguirre Riofrio *et al.*, 2016; Mellado *et al.*, 2016; Moreira *et al.*, 2016; Sieklicki *et al.*, 2016).

According to genotype and growing characteristic of lambs is necessary to formulate breeding programmes to improve efficiency of animals (Daskiran *et al.*, 2010; Keskin *et al.*, 2009). Growth performance of the local sheep genotypes is essential in planning breeding programs to improve the amount of meat, milk and wool production of these genotypes. There is very little knowledge about the growth intensity of sheep breeds and their crosses bred in Slovakia. The objective of presented paper was to evaluate the growth curves in lambs and the shape of their growth curves in different stages of rearing (before weaning and after weaning). The rearing method of lambs was realized so, that it can express their genetic potential as much as possible.

MATERIALS AND METHODS

In the Slovak Republic, the dairy flocks used are mainly Improved Valachian (IV) sheep and Tsigai (T) and considerable attention is devoted to research into their production, breeding and hybridization (Makovický *et al.*, 2013a,b; 2014a,b; 2015a,b,c,d). Lacaune (LC) breed is also ranked among most important dairy sheep breed, however this breed originated from France and its milk is there above all used for making a cheese called Roquefort (Novotná *et al.*, 2007; 2009; Pokorná *et al.*, 2009; Konečná *et al.*, 2013). To improve meat production and carcass quality, about 10 % of the ewe population is crossed with rams purchased from meat breed populations. As for the meat production of Tsigai sheep, they are most frequently crossed with meat type rams, mainly with Suffolk sires.

Investigations were performed at the Sheep Station of the Animal Production Research Centre Nitra. All lambs included in the experiment were bred under the same conditions (including nutrition of ewes and lambs) throughout the whole experimental period. The nursery system was designed according to modified methods reported by Margetín *et al.* (2003). The lambs were allowed to leave the nursery in accordance with the time schedule proposed. In the beginning of the experiment, the nursery was opened the whole night for two weeks. Later, the nursery was closed at night since 11 p.m. The nursery, in which lambs were kept, was of dimensions 5 × 2.5 m. The group pen, in which ewes were kept, was of dimensions 10.5 × 2.5 m. All born and viable purebred lambs of Improved Valachian (IV) breed, Lacaune (LC) were gradually included in the experiment, and also crossbreeds of IV x LC with 25 %, 37.5 %, 50 % and 75 % proportion of LC (1st experimental group), and also purebred Tsigai (T) lambs, crossbreeds of T x LC with 25 % and 50 % proportion of LC, and crossbreeds T x Suffolk (SF) (2nd experimental group). All lambs were weighed on a digital scale with an accuracy of 0.1 kg at birth, and then every week until weaning (8 weightings totally). After weaning only breeding ewes and ram lambs were weighed (totally 6 times) and kept for further farming. All breeding ewes and ram lambs were cropped after the penultimate (13th) weighing. On the basis of each weighing, weights of lambs were calculated and analyzed using linear interpolation from 1 to 8 weeks (before weaning), and weights of lambs at age 60, 80, 120, 150, 210, and 270 days (after weaning). Multifactorial analysis of variance and covariance using a linear model with fixed effects was used for evaluation of primary data. In both experimental groups in each model were included in the genotype of individuals (6 genotypes in the 1st group, 5 genotypes in the 2nd group), the litter size (single litters respectively multiple litters); the age of mothers (7 groups: from 2 to 8 years of age), gender of lambs (female and male) and the age of lambs at each weighting. For primary data analysis the mathematical and statistical software package SAS/STAT 1999–2001 ver. 8.2 (GLM procedure) was used. For determining the shape of growth curves of lambs in various stages of rearing, and also for the whole monitored period (from birth of lambs to 9th months of age) the graph editor of Microsoft Excel – MS Office software package was used. By analysing data with the help of line graphs, we found out – both for the first and second experimnetal group separately, what influence does the genotype, gender and litter size have on the growth curve of lambs. The most appropriate regression equation for each stage of rearing and the most appropriate trend line (growth curve) was determined based on the averages provided by Excel, taking into consideration the coefficients of calculability and determination (R2).

RESULTS AND DISCUSSION

Tab. I shows the weight of six genotypes of lambs, observed within the first experimental group and Tab. II shows five genotypes observed in the second experimental group, depending on their rearing period. The above data are estimates averages (least-squares means) reflecting the impact of systematic factors (gender, mother age, litter size). The data can therefore serve to farmers as

I: *The average weight of lambs (LSM±SD) before weaning and after weaning according to different genotypes – lambs generated based on breed Improved Valachian*

Markers	Improved Valachian (IV) (1)	IV x LC (25 % LC) (2)	IV x LC (37.5 % LC) (3)	IV x LC (50 % LC) (4)	IV x LC (75 % LC) (5)	Lacaune (LC) (6)	Total averages
	Genotypes of the individuals						
Lambs weight before weaning (kg)							
At birth	4.78 ± 0.11	5.08 ± 0.18	4.82 ± 0.17	4.83 ± 0.18	4.81 ± 0.17	4.18 ± 0.13	4.71 ± 0.81 *1
7 days old (1st week)	8.51 ± 0.31	9.01 ± 0.51	8.32 ± 0.55	9.05 ± 0.50	8.83 ± 0.45	8.05 ± 0.40	8.55 ± 1.55
14 days old (2nd week)	9.55 ± 0.26	9.92 ± 0.45	9.50 ± 0.39	9.41 ± 0.51	9.81 ± 0.47	10.03 ± 0.32	9.70 ± 1.89
21 days old (3rd week)	10.62 ± 0.27	11.14 ± 0.45	10.68 ± 0.41	10.95 ± 0.46	10.75 ± 0.43	10.81 ± 0.37	10.69 ± 2.03
28 days old (4th week)	11.85 ± 0.31	12.66 ± 0.54	12.51 ± 0.50	12.43 ± 0.54	12.33 ± 0.52	12.13 ± 0.42	12.24 ± 2.47
35 days old (5th week)	14.06 ± 0.35	14.36 ± 0.61	14.65 ± 0.55	14.38 ± 0.60	14.57 ± 0.58	14.59 ± 0.50	14.27 ± 2.74
42 days old (6th week)	15.73 ± 0.41	16.70 ± 0.71	16.74 ± 0.64	16.79 ± 0.70	16.87 ± 0.67	16.78 ± 0.67	16.26 ± 3.17
49 days old (7th week)	16.76 ± 0.47	18.75 ± 0.85	18.87 ± 0.77	18.93 ± 0.78	19.07 ± 0.75	18.68 ± 0.82	18.30 ± 3.53
56 days old (8th week)	19.88 ± 0.60	20.36 ± 1.29	20.55 ± 0.96	20.32 ± 0.90	20.22 ± 0.84	21.of 02 ± 2.23	19.93 ± 3.55
63 days old (9th week)	22.37 ± 1.03	23.32 ± 1.90	22.39 ± 1.72	22.92 ± 1.14	23.59 ± 1.08	21.80 ± 2.55	22.88 ± 3.90
Lambs weight after weaning (kg)							
60 days old	26.98 ± 0.79	27.57 ± 0.17	29.81 ± 1.10	28.14 ± 0.94	27.91 ± 1.01	28.86 ± 0.70	27.04 ± 3.59
80 days old	34.14 ± 1.01	34.65 ± 1.28	37.45 ± 1.27	35.07 ± 1.11	36.33 ± 1.16	38.69 ± 0.81	35.36 ± 3.92 *2
120 days old	38.13 ± 1.14	39.39 ± 1.44	41.77 ± 1.42	40.54 ± 1.21	41.39 ± 1.32	43.82 ± 0.92	40.15 ± 4.39 *3
150 days old	38.61 ± 1.23	41.37 ± 1.55	43.97 ± 1.53	42.75 ± 1.29	43.22 ± 1.41	44.99 ± 1.00	41.50 ± 4.73 *4
210 days old	41.23 ± 1.46	44.04 ± 1.86	47.45 ± 1.83	45.54 ± 1.55	46.13 ± 1.75	49.59 ± 1.21	44.94 ± 5.67 *5

*1 – Significant differences: 6:1,2+++;6:3,4,5++;
*2 – Significant differences: 6:1,2++; 6:4+; 1:3+;
*3 – Significant differences: 6:1,2++; 6:4+; 1:3,5+;
*4 – Significant differences: 6:1+++; 6:2+; 1:3,4,5++;
*5 – Significant differences: 6:1+++; 6:2+; 1:3++; 1:4,5+;

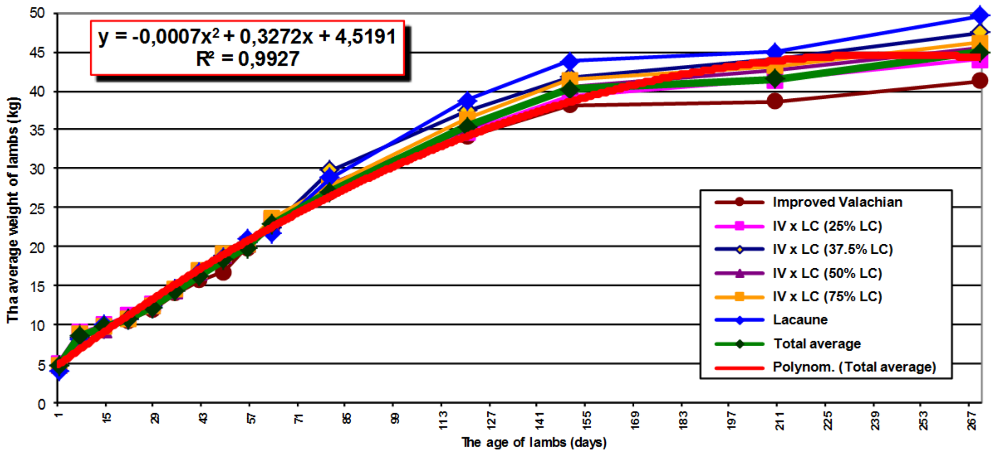
a comparative table of lamb weight in various stages of rearing (before weaning and after weaning). Tab. I and Tab. II shows that most lambs in the studied population reached the weigt ideal for dairy slaughter lambs within 4–5 weeks, using the selected method. On average the lambs of the 1st group reached the weight of 12.24 kg on 28th day, and up to 14.27 kg on 35th day (Tab. I), respectively the weight of 11.63 kg and 13.57 kg in the second group (Tab. II). The proportion of ewes and ram lambs was approximately equal in the study population. IV lambs have reached the weight of 14.06 ± 0.35 kg and T bred lambs the weight of 13.63 ± 0.22 kg at the age of 35th days. The differences in growth curves between the lambs of monitored genotypes before weaning were minimal and non-significant (Fig. 1 and 2). Differences between the two compared genotypes were in relation to their weight in various stages of rearing before weaning, in most cases statistically non-significant. The growth of lambs after weaning in the first experimental group can be expressed by linear regression equation $y = 0.2659x + 5.352$ (x = age of lambs in days; $R^2 = 0.985$), and in the second group using regression equation $y = 4.7364 + 0.2404x$ ($R^2 = 0.9954$). Differences in weight between the different

II: *The average weight of lambs (LSM ± SD) before weaning and after weaning according to different genotypes depending on their age – lambs generated based on breed Tsigai*

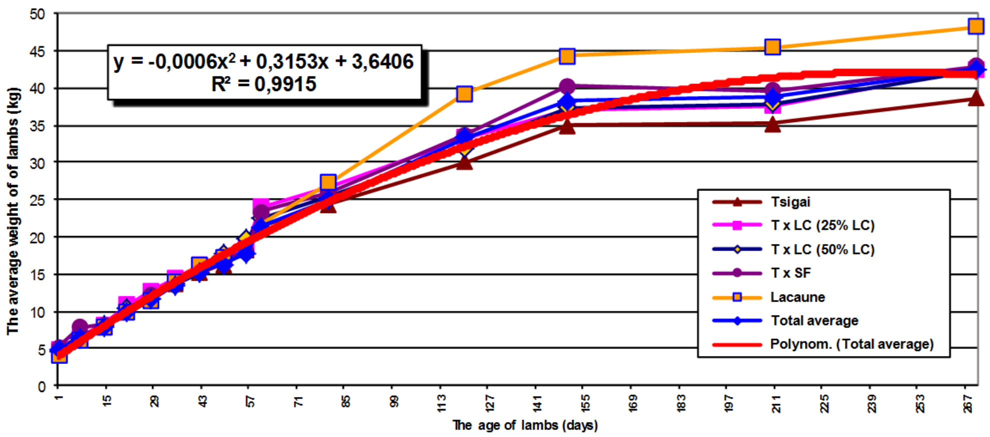
Markers	Genotypes of the individuals					Total averages
	Tsigai (T) (1)	T x LC (25 % LC) (2)	T x LC (50 % LC) (3)	T x Suffolk (SF) (4)	Lacaune (LC) (5)	
Lambs weight before weaning (kg)						
At birth	4.91 ± 0.08	4.84 ± 0.17	4.70 ± 0.18	5.15 ± 0.19	4.19 ± 0.12	4.73 ± 0.73 *1
7 days old (1st week)	6.59 ± 0.17	6.48 ± 0.42	6.56 ± 0.41	7.86 ± 0.43	6.06 ± 0.32	6.47 ± 1.53 *2
14 days old (2nd week)	7.84 ± 0.17	8.21 ± 0.40	8.04 ± 0.37	8.19 ± 0.42	7.90 ± 0.26	7.82 ± 1.46
21 days old (3rd week)	9.88 ± 0.20	10.85 ± 0.46	10.49 ± 0.47	9.98 ± 0.49	9.99 ± 0.33	9.95 ± 1.75
28 days old (4th week)	11.61 ± 0.20	12.69 ± 0.47	11.76 ± 0.45	12.25 ± 0.49	11.47 ± 0.37	11.63 ± 1.77
35 days old (5th week)	13.63 ± 0.22	14.44 ± 0.53	13.63 ± 0.51	13.86 ± 0.55	13.89 ± 0.43	13.57 ± 1.98
42 days old (6th week)	15.11 ± 0.28	16.22 ± 0.67	15.17 ± 0.64	15.50 ± 0.68	16.30 ± 0.59	15.23 ± 2.42
49 days old (7th week)	16.28 ± 0.32	17.03 ± 0.69	17.63 ± 0.68	16.92 ± 0.73	17.27 ± 1.37	16.29 ± 2.17
56 days old (8th week)	18.29 ± 0.38	18.83 ± 0.80	19.68 ± 0.91	18.11 ± 0.92	-	17.77 ± 2.44
Lambs weight after weaning (kg)						
60 days old	21.39 ± 0.51	24.05 ± 0.93	22.47 ± 0.86	23.42 ± 0.93	21.69 ± 0.69	21.29 ± 3.01 *3
80 days old	24.41 ± 0.54	26.71 ± 0.87	25.42 ± 0.88	25.96 ± 0.98	27.28 ± 0.70	25.01 ± 3.10 *4
120 days old	30.08 ± 0.72	33.33 ± 1.36	31.94 ± 1.14	33.74 ± 1.48	39.26 ± 0.81	33.38 ± 3.92 *5
150 days old	34.98 ± 0.89	37.11 ± 1.68	37.44 ± 1.34	40.24 ± 1.82	44.29 ± 0.99	38.31 ± 4.86 *6
210 days old	35.21 ± 0.88	37.59 ± 1.56	37.93 ± 1.36	39.66 ± 1.81	45.48 ± 1.01	38.82 ± 4.77 *7
270 days old	38.65 ± 1.38	42.60 ± 2.90	42.39 ± 2.08	42.94 ± 2.86	48.31 ± 1.56	42.53 ± 7.48 *8

*1 – Significant differences: 5:1,4+++; 5:2++; 5:1+;
*2 – Significant differences: 4:1++; 4:2,3+; 4:5++;
*3 – Significant differences: 1:2+;
*4 – Significant differences: 1:5++; 1:2+;
*5 – Significant differences: 5:1,2,3+++; 5:4++; 1:2,4+;
*6 – Significant differences: 5:1,3+++; 5:2++; 1:4++;
*7 – Significant differences: 5:1,2,3+++; 5:4++; 1:3,4+;
*8 – Significant differences: 5:1+++; 5:3+;

genotypes progressively increased after weaning, manifesting the different genetic predisposition for the growth of different breeds of lambs (Fig. 1 and 2). At the age of 150 days the lambs had an average of 40.15 kg respectively 38.31 kg (Tab. I and Tab. II). The lowest weight had IV breed lambs (38.46 ± 1.13 kg) and T lambs (34.98 ± 0.89 kg), while the highest had the LC breed lambs (43.82 ± 0.92 kg, respectively 44.29 ± 0.99 kg). Differences between genotypes were statistically highly significant ($P < 0.001$). At the age of nine months the differences were even more significant and lambs in the studied populations have reached the averaged of weight 44.94 ± 5.81 kg respectively 42.53 ± 7.48 kg. Ewes of the first group reached weight 41.77 kg at this age, and ram lambs 49.55 kg. Singleton lambs reached 46.52 kg, and lambs from the multiple litters 44.81 kg. Ewes of the second group at the age of 270 days reached the weight of 42.89 kg, and ram lambs 43.07 kg. Singleton lambs reached 44.26 kg



1: *Growth curves of lambs of different genotypes generated based on breeds Improved Valachian and Lacaune*



2: *Growth curves of lambs of different genotypes generated based on breeds Tsigai and Lacaune*

and lambs from the multiple litters 41.69 kg. Lambs growth in the first group at this stage of rearing can be best expressed by the logarithmic regression equation $y = 14.126\ln(x) - 33.188$ ($R^2 = 0.9385$) and in the second group with regression equation $y = 14.414\ln(x) - 36.971$ ($R^2 = 0.9542$). Fig. 1 shows the growth curves of lambs of different genotypes generated based on breed Improved Valachian, and Fig. 2 shows the growth curves generated based on breed Tsigai. It is evident from the two figures that the growth of lambs in this the rearing phase can be best expressed by polynomial regression equations – for the lambs in 1st group $y = -0.0007x^2 + 0.3272x + 4.5191$ + (x = age of lamb in days), and for the lambs in the second group $y = -0.0006x^2 + 0.3153x + 3.6406$. In both cases, the coefficient of determination (R^2) is approaching to the value 1 – in the first group R^2 value reached 0.9927, and in the second group 0.9915. The differences in the regression equation between the two groups are minimal, so the numbers can be used in predicting the weight of the lambs if the farmer wants to know how much weight the lambs should achieved during the different rearing phases. From both figures is also clear that the genetic predisposition of LC lambs and their crosses grew more in the second rearing phase (after weaning). It is connected to early maturity of improved LC breed. Our results clearly show that LC ewes and ram lambs, and also their crosses with higher proportion of the LC breed, can be used in breeding as early as the first year of life.

CONCLUSION

Our findings regarding the growth particularly in ewes and ram lambs might be best expressed by using polynomal regression equations. The same is valid for singleton lambs and lambs from the multiple litters. The coefficients of determination (R^2) of observed regression equations always reached values greater than 0.99.

Acknowledgments

The study was performed during the realization of the project MLIEKO 26220220098 funded by the Operational Program for Research and Development of the European Regional Development Fund.

REFERENCES

AGUIRRE RIOFRIO, E.L., FERRAZ, J.B.S. and MATTOS, E.C. 2016. Influence of non-genetic factors on growth and reproductive traits of sheep Santa Inês in extensive systems. *Livestock Research for Rural Development, 28(7): #121. [Online].* Available at: http://www.lrrd.org/lrrd28/7/agui28121.html [Accessed: 2016, October 26].

AKTAS, A.H., ANKARALI, B., HALICI, I., DEMIRCI, U., ATIK, A. and YAYLACI, E. 2014. Growth traits and survival rates of Akkaraman lambs in breeder flocks in Konya Province. *Turk. J. Vet. Anim. Sci.,* 38: 40–45.

BAHREINI BEHZADI, M.R., ASLAMINEJAD, A.A., SHARIFI, A.R. and SIMIANER, H. 2014. Comparison of mathematical models for describing the growth of Baluchi Sheep. *J. Agr. Sci. Tech.,* 14: 57–68.

DASKIRAN, I., KONCAGUL, S. and BINGOL, M. 2010. Growth characteristics of indigenous Norduz female and male lambs. *Tar. Bil. Der.,* 16: 62–69.

DOBEŠ, I., KUCHTÍK, J., PETR, R. and FILIPČÍK, R. 2007. Effect of chosen factors on growth of lambs crossbreeds with using Suffolk in sire position. *Acta Univ. Agric. et Silvic. Mendel. Brun.,* 55: 27–32.

GHAVI HOSSEIN-ZADEH, N.G. 2015. Modeling the growth curve of Iranian Shall sheep using non-linear growth models. *Small Rumin. Res.,* 130: 60–66.

HOŠEK, M., KONEČNÁ, L., KUCHTÍK, J. and FILIPČÍK, R. 2008. Effect of breed, sex and litter size on growth and meat-iness and fattiness in vivo in lambs. *Acta Univ. Agric. et Silvic. Mendel. Brun.,* 56: 231–237.

KESKIN, I., DAG, B., SARIYEL, V. and GOKMEN, M. 2009. Estimation of growth curve parameters in Konya Merino sheep. *S. Afr. J. Anim. Sci.,* 39: 163–168.

KOMPRDA, T., KUCHTÍK, J., JAROŠOVÁ, A., DRÁČKOVÁ, E., ZEMÁNEK, L. and FILIPČÍK, R. 2012. Meat quality characteristics of lambs of three organically raised breeds. *Meat Sci.,* 91: 499–505.

KONCAGUL, S., VURAL, M.E., KARATAS, A., AKCA, N. and BINGOL, M. 2013. Reproductive performance of ewes and growth characteristics of lambs in Zom Sheep reared in Karacadağ District. *Kafkas Univ. Vet. Fak. Derg.,* 19: 63–68.

KONEČNÁ, L., KUCHTÍK, J., KRÁLÍČKOVÁ Š., POKORNÁ, M., ŠUSTOVÁ, K., FILIPČÍK, R. and LUŽOVÁ, T. 2013. Effect of different crossbreeds of Lacaune and East Friesian breeds on milk yield and basic milk parameters. *Acta Univ. Agric. et Silvic. Mendel. Brun.,* 11: 93–98.

KOPUZLU, S., SEZGIN, E., ESENBUGA, N. and BILGIN, O.C. 2014. Estimation of growth curve characteristics of Hemsin male and female sheep. *J. Appl. Anim. Res.,* 42, 228–232.

KOUTNÁ, S., KUCHTÍK J. and FILIPČÍK, R. 2016. Effect of genotype on growth and basic carcass characteristics in male lambs. *Acta Univ. Agric. et Silvic. Mendel. Brun.,* 64: 821–824.

KUCHTÍK, J. and HORÁK, F. 2007. Effect of breed and different crossbreeds of lambs males on meat quality. *Acta Univ. Agric. et Silvic. Mendel. Brun.,* 55: 37–42.

KUCHTÍK, J., DOBEŠ, I. and HEGEDÜŠOVÁ, Z. 2010. Growth of lambs of crossbreeds of Romanov, Suffolk and Charollais breeds – effect of sex, litter size and season. *Acta Univ. Agric. et Silvic. Mendel. Brun.,* 58: pp. 233–238.

KUCHTÍK, J., DOBEŠ, I. and HEGEDÜŠOVÁ, Z. 2011. Effect of genotype, sex and litter size on growth and basic traits of carcass quality of light lambs. *Acta Univ. Agric. et Silvic. Mendel. Brun.,* 59: 111–116.

LUPI, T. M., NOGALES, S., LEÓN, J. M., BARBA, C. and DELGADO, J. V. 2015. Characterization of commercial and biological growth curves in the Segureña sheep breed. *Animal,* 9: 1341–1348.

MAKOVICKÝ, Pa., NAGY, M. and MAKOVICKÝ, Pe. 2013a. Comparison of external udder measurements of the sheep breeds Improved Valachian, Tsigai, Lacaune and their crosses. *Chil. J. Agr. Res.,* 73: 366–371.

MAKOVICKÝ, Pa, NAGY, M., MAKOVICKÝ, Pe. and SZINETÁR, Cs. 2013b. Milk quality comparison of the sheep breeds (Improved Valachian, Tsigai, Lacaune) and their crosses. *Magy Allatorvosok,* 135: 85–90.

MAKOVICKÝ, Pa., NAGY, M. and MAKOVICKÝ, Pe. 2014a. The comparison of ewe udder morphology traits of Improved Valachian, Tsigai, Lacaune breeds and their crosses. *Mljekarstvo,* 64: 86–93.

MAKOVICKÝ, Pa., MAKOVICKÝ, PE., NAGY, M., RIMÁROVÁ, K. and DIABELKOVÁ, J. 2014b. Genetic parameters for Somatic cell count, LOGSCC and Somatic cell score among breeds: Improved Valachian, Tsigai, Lacaune and their crosses. *Acta Vet-Beograd*, 64: 386–396.
MAKOVICKÝ, Pa., MARGETÍN, M. and MAKOVICKÝ, Pe. 2015a. Genetic parameters for the linear udder traits of nine dairy ewes – short communication. *Vet. Arhiv*, 85: 577–582.
MAKOVICKÝ, Pa., MARGETÍN, M. and MILERSKI, M. 2015b. Estimation of udder cistern size in dairy ewes by ultrasonography. *Mljekarstvo*, 65: 210–218.
MAKOVICKÝ, Pa., RIMÁROVÁ, K., MAKOVICKÝ, Pe. and NAGY, M. 2015c. Genetic parameters for external udder traits of different dairy ewes. *Indian J. Anim. Sci.*, 85: 89–90.
MAKOVICKÝ, Pa., MILERSKI, M., MARGETÍN, M., MAKOVICKÝ, Pe. and NAGY, M. 2015d. Genetic parameters for the size of udder cisterns in ewes diagnosed by ultrasonography among breeds: Improved Valachian, Tsigai, Lacaune and their crosses. *Arch. Zootec.*, 64: 403–408.
MARGETÍN, M., ČAPISTRÁK, A., APOLEN, D., ŠPÁNIK, J., BULLOVÁ, M. and ŠÁNDOR, E. 2003. Ewes breeding with high milk yield in the first months of lactation. In: *Najnovšie poznatky genetického hodnotenia, výživy, a technológie v chove oviec.* Zborník prednášok z odborného seminára s medzinárodnou účasťou, VÚŽV Nitra, 2003. 55–62.
MELLADO, M., MACIAS, U., AVENDANO, L., MELLADO, J. and GARCÌA, J. E. 2016. Growth and pre-weaning mortality of Katahdin lamb crosses. *Rev. Colomb. Cienc. Pecu.*, 29: 288–295.
MOREIRA, R. P., PEDROSA, V. B., FALCAO, P.R., SIEKLICKI, M. F., ROCHA, C. G., DOS SANTOS, I. C., FERREIRA, E. M. and DE SOUZA MARTINS, A. 2016. Growth curves for Ile de France female sheep raised in feedlot. *Semin: Cien. Agrar.*, 37: 303–310.
NOVOTNÁ, L., KUCHTÍK, J., DOBEŠ, I., ŠUSTOVÁ, K. and ZAJÍCOVÁ, P. 2007. Effect of somatic cell count on ewe's milk composition, its properties and the quality of rennet curd. *Acta Univ. Agric. et Silvic. Mendel. Brun.*, 8: 59–64.
NOVOTNÁ, L., KUCHTÍK, J., ŠUSTOVÁ, K., ZAPLETAL, D. and FILIPČÍK, R. 2009. Effects of the lactation stage and parity on milk yield, composition and properties of organic sheep milk. *J. Appl. Anim. Res.*, 36: 71–76.
PAJOR, F., LACZÓ, E. and PÓTI, P. 2007. Sustainable sheep production: Evaluation of effect of temperament on lamb production. *Cereal Res. Commun.*, 35: 873–876.
PAJOR, F., SZENTLELEKI, A., LACZÓ, E., TOZSER, J. and PÓTI, P. 2008. The effect of temperament on weight gain of Hungarian Merino, German Merino and German Blackhead lambs. *Arch. Tierz. Dummerstorf*, 51: 247–254.
PAJOR, F., LACZÓ, E., ERDOS, O. and PÓTI, P. 2009a. Effects of crossbreeding Hungarian Merino sheep with Suffolk and Ile de France on carcass traits. *Arch. Tierz.*, 52: 169–176.
PAJOR, F., SZENTLELEKI, A., TOZSER, J. and PÓTI, P. 2009b. Effect of biotic stress on growth performance of Tsigai lambs. *Cereal Res. Commun.*, 37: 627–630.
PAJOR, F., MURÁNYI, A., SZENTLELEKI, A., TOZSER, J. and PÓTI, P. 2010. Effect of temperament of ewes on their maternal ability and their lambs' postweaning traits in Tsigai breed. *Arch. Tierz.*, 53: 465–474.
PETR, R., DOBEŠ, I. and KUCHTÍK, J. 2009. Evaluation of the growth, meatiness and fattines in vivo of chosen breeds and crossbreeds. *Acta Univ. Agric. Silvic. Mendelianae Brun.*, 57: 79–86.
POKORNÁ, M., KUCHTÍK, J., ŠUSTOVÁ, K., LUŽOVÁ, T. and FILIPČÍK, R. 2009. Milk yield, composition and quality of organic milk of ewes crossbreeds of Lacaune, East Friesian and Improved Wallachian during lactation. *Acta Univ. Agric. et Silvic. Mendel. Brun.*, 9: 87–94.
PTÁČEK, M., ŠTOLC, L., STÁDNÍK, L. and KLUKOVÁ, H. 2013. In vivo assessment of growth traits and meat production in Charollais and Kent lambs. *Scientia Agriculturae Bohemica*, 44: 10–17.
PTÁČEK, M., DUCHÁČEK, J., STÁDNÍK, L., BERAN, J. and NĚMEČKOVÁ, D. 2015. Influence of selected factors on growth performance of Suffolk lambs and their crossbreds. *Journal of Central European Agriculture*, 16: 188–196.
SAS INSTITUTE Inc. 1999–2001. *SAS/STAT Version 8.2.* Cary, NC: SAS Institute Inc.
SEN, U., KURAN, M. and ENSOY, U. 2013. Growth performance, carcass and meat quality of Karayaka female lambs born in different seasons. *Arch. Tierz.*, 56: 315–327.
SIEKLICKI, M.F., PEDROSA, V.B., ROCHA, C.G., MOREIRA, R.P., FALCAO, P.R., DOS SANTOS, I.C., FERREIRA, E.M. and DE SOUZA MARTINS, A. 2016. Growth curves of Texel male lambs. *Acta Sci. Vet.*, 44: 1396.
SVITÁKOVÁ, A., SCHMIDOVÁ, J., PEŠEK, P. and NOVOTNÁ, A. 2014. Recent developments in cattle, pig, sheep and horse breeding – a review. *Acta Vet. Brno*, 83: 327–340.
ŠTOLC, L., PTÁČEK, M., STÁDNÍK, L. and LUX, M. 2011. Effect of selected factors on basic reproduction, growth and carcass traits and meat production in Texel sheep. *Acta Univ. Agric. et Silvic. Mendel. Brun.*, 59: 247–252.
ULUTAS, Z., SEZER, M., AKSOY, Y., SIRIN, E., SEN, U., KURAN, M. and AKBAS, Y. 2010. The effect of birth types on growth curve parameters of Karayaka lamb. *J. Anim. Vet. Adv.*, 9: 1384–1388.

WAHEED, A., EYDURAN, E., TARIQ, M.M., AHMAD, S., HAMEED, T. and BUKHARI, F.A. 2015. Comparison of the non-linear models defining the growth of Thalli sheep under desert conditions. *Pakistan J. Zool.,* 48: 423–426.

WOLFOVÁ, M., WOLF, J. and MILERSKI, M. 2009. Calculating economic values for growth and functional traits in non-dairy sheep. *J. Anim. Breed. Genet.,* 126: 480–491.

ZAPLETAL, D., KUCHTÍK, J. and DOBEŠ, I. 2010. The effect of genotype on the chemical and fatty acid composition of the *Quadriceps femoris* muscle in extensively fattened lambs. *Arch. Tierz.,* 53: 589–599.

Contact information

Pavol Makovický: makovicky.pavol@gmail.com
Milan Margetín: milan.margetin@uniag.sk
Melinda Nagy: nagymelinda@gmail.com
Peter Makovický: pmakovicky@email.cz