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FIRST ESTIMATES OF LACTATION CURVES IN WHITE SHORTHAIRED GOATS IN SLOVAKIA

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ABSTRACT

The objective of this study was to compare Cubic, Ali-Schaeffer, Guo-Swalve (modified Khanderkar) and Wilmink models for fitting lactation curves of White Shorthaired goats in Slovakia. In total, 19 002 test day records of daily milk yield, 18 441 test day records of fat content and 18 757 test day records of protein content of 1 486 does collected between 1996 and 2011, were analyzed. Milk traits were grouped by the week of lactation, and hence weekly averages of milk yield, fat and protein content were used for modelling the first estimates of lactation curves. The goodness-of-fit of the models was of similar quality (R^2 slightly above 0.9 for milk yield, above 0.6 for fat content and above 0.7 for protein content); with the exception of Wilmink model which gave lower R^2 for the three traits (0.842, 0.600, 0.426). Lack of data in early and late lactation caused some difficulties in modelling the respective phases of lactation curves with chosen models. The greatest differences in lactation curves were found between Wilmink model and the remaining models. Research on individual days in milk is needed for better understanding of variation of milk traits during the course of lactation, since they may depend on such effects as number of kids, feeding, parity or individual doe.

Keywords: doe, White Shorthaired goat, test day, lactation, milk traits, weekly averages, regression coefficient

INTRODUCTION

The White Shorthaired goats are predominant among the goat population of Slovakia. Goats represent the livestock sector of minor importance, mainly farmed for milk. The production system is extensive with the only one kidding per year applied. The performance testing involves few flocks of the White Shorthaired goats; the numbers have been gradually decreasing since the beginning of the millennium. Selection is done under the umbrella of the Sheep and Goat Breeders' Association and the Breeding Services of the Slovak Republic. Breeding is aimed at improvement of milk, prolificacy and exterior. The animals are selected on the basis of 100-point scale (55 points for milk yield, 25 points for prolificacy and 20 points for exterior). Milk yield expressed as milk yield adjusted for 240-day standardized milking period is considered the most important trait among Slovak goats (milking period starts after the kids are weaned).

Although goat lactation curves and factors affecting variation of daily milk traits are commonly known worldwide (Akpa *et al*., 2001; Ciappesoni at al., 2004; Macciotta *et al*., 2005; Pala and Savas, 2005; Waheed and Khan, 2013), the only analysis done with goats in Slovakia is the study dealing with milking period yield (Margetín and Milerski, 2000). In small ruminants, daily milk traits were analyzed only in Slovak sheep and ewes' lactation curves were estimated (Oravcová *et al.*, 2006 and 2007).

The objective of this study was to study the variation of goat milk, fat and protein content throughout the lactation and to estimate average lactation curves for milk yield, fat and protein content in White Shorthaired goats in Slovakia.

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MATERIAL AND METHODS

Test-day records of milk performance testing in a single (most numerous) flock of the purebred White Shorthaired goats collected by the Breeding Services of the Slovak Republic between years 1996 and 2011, were analyzed. The traits investigated were daily milk yield, fat and protein content. Milk samples were taken in accordance with A_4 or AC standard method (ICAR, 2003). In total, 19 002 test day records of daily milk yield, 18 441 test day records of fat content and 18 757 test day records of protein content of 1 486 does on their 1st to 10th parities (3 646 parities) were included in the analysis. The average number of test-day measurements per parity was 5.22 ± 0.88; almost 90 % of does had 5 or 6 test days per lactation. The measurements, taken between days 17 and 251 after parturition, were grouped by the week of lactation. Thus, week averages of the respective traits were used for modelling the first estimates of lactation curves in Slovak goats. The following models: Cubic, Ali-Schaeffer (1987), Guo-Swalve (1995) i.e. modified Khanderkar and Wilmink (1987) were applied (GLM procedure, SAS 9.2 software; 2009) for modelling of first estimates of lactation curves for milk yield, fat and protein content in goats of the White Shorthaired breed.

Cubic model:

$$y = b_0 + b_1 DIM + b_2 DIM^2 + b_a DIM^a + e \quad (1)$$

Ali-Schaeffer model:

$$y = b_0 + b_1\left(\frac{DIM}{240}\right) + b_2\left(\frac{DIM}{240}\right)^2 + b_a \ln\left(\frac{240}{DIM}\right) + b_4 \ln\left(\frac{240}{DIM}\right)^2 + e \quad (2)$$

Guo-Swalve model (modified Khanderkar):

$$y = b_0 + b_1 DIM + b_2 DIM^2 + b_a DIM^a + b_4 \ln(DIM^l) + e \quad (3)$$

Wilmink model:

$$y = b_0 + b_1 2.718281^{-0.05DIM} + b_2 DIM + e \quad (4)$$

where:
y is weekly averages of daily milk yield, fat and protein content; b_0 to b_4 is regression coefficients; ln is natural logarithm; 2.718281 is base of natural logarithm; 240 is length of standardized lactation period; *DIM* is days in milk; e is random error assumed to be normally distributed, N is $(0, \partial_e^z)$

The goodness-of-fit of the models was assessed by comparison of coefficients of determination and residual standard deviations.

RESULTS AND DISCUSSION

In the analyzed performance records of White Shorthaired goats in Slovakia, the average number of days in milk from parturition to the first test day was 60 ± 15.9. Most measurements (81.2 %) were taken in the middle of lactation (months 3 to 7), whereas in the beginning of lactation (week 3, 4 and 5) and the end of lactation (week 33, 34 and 35) minimum measurements were done (see Table 1 for distribution of test days by the week of lactation). Some monthly measurements lacked the information on milk composition (3 % for fat content and 1.3 % for protein content).

The estimated regression coefficients for Cubic, Ali-Schaeffer, Guo-Swalve (modified Khanderkar) and Wilmink model are given in Tables 2 (for milk yield), 3 (for fat content) and 4 (for protein content). The goodness-of-fit of the models is also given. The coefficients of determination (R^2) were almost identical or similar within the individual milk traits. The models explained from 84.2 % to 91.5 % of total variability for milk yield (Table 2), from 60.0 % to 69.9 % for fat content (Table 3) and from 42.6 % to 71.3 % for protein content (Table 4). Wilmink model explained the lowest amount of total variability for the three traits investigated: about 7 % lower variability than the remaining models for milk yield, about 10 % lower variability for fat content and about 30 % lower variability for protein content. The goodness-of-fit differed minimally among Cubic, Ali-Schaeffer and Guo-Swalve (modified Khanderkar) models: from 0.1 % to 0.4 % for milk yield, from 0.8 % to 2.9 % for fat content and from 0.1 % to 0.4 % for protein content. After fitting the models, standard deviations for milk traits diminished as follows: from 55.5 % to 66.4 % for milk yield (Table 2), from 34.5 % to 56.5 % for fat content (Table 3) and from 21.7 % to 45.4 % for protein content (Table 4).

The slightly higher coefficients of determination (above 92 %) were reported by Ángel Marín *et al.* (2009) when fitting four mathematical models (Wood, Brody, Wilmink, and Papayscik- Bodero) to milk lactation curves in Colombian hybrid goats with 865 daily milk yields measured. Comparable coefficients of determination (from 89.27 to 97.82 %) to those found in this study were reported by León *et al.* (2012) when fitting six mathematical models (Wood, modified Wood, Cobby-Le Du, Wilmink, Quadratic spline, and Legendre polynomials of order three) to milk lactation curves in Murciano-Granadina goats. The authors used the mean daily milk production in the individual day of lactation

Table 1: Weekly averages for milk yield, fat and protein content

Week	Days	N	Milk, l	N	Fat (%)	N	Protein (%)
			$x \pm s$		$x \pm s$		
3	15 to 21	3	0.843 ± 0.455	3	4.03 ± 0.41	3	3.12 ± 0.14
4	22 to 28	5	1.173 ± 0.499	5	4.72 ± 0.88	5	3.16 ± 0.31
5	29 to 35	7	1.464 ± 0.609	7	4.42 ± 0.58	7	3.14 ± 0.32
6	36 to 42	156	1.566 ± 0.481	139	3.64 ± 0.89	128	2.91 ± 0.32
7	43 to 49	645	1.527 ± 0.479	604	3.39 ± 0.67	616	2.84 ± 0.29
8	50 to 56	610	1.634 ± 0.507	509	3.38 ± 0.66	609	2.76 ± 0.37
9	57 to 63	983	1.725 ± 0.498	880	3.29 ± 0.79	980	2.68 ± 0.33
10	64 to 70	930	1.839 ± 0.504	901	3.42 ± 0.70	925	2.76 ± 0.29
11	71 to 77	709	1.724 ± 0.519	665	3.41 ± 0.71	667	2.83 ± 0.25
12	78 to 84	539	1.861 ± 0.661	512	3.12 ± 0.90	538	2.73 ± 0.29
13	85 to 91	1028	1.817 ± 0.532	983	3.17 ± 0.79	1028	2.68 ± 0.38
14	92 to 98	927	1.894 ± 0.612	914	3.23 ± 0.67	921	2.73 ± 0.26
15	99 to 105	620	1.952 ± 0.673	620	3.34 ± 0.63	620	2.77 ± 0.28
16	106 to 112	702	1.800 ± 0.609	701	3.29 ± 0.65	701	2.81 ± 0.24
17	113 to 119	866	1.794 ± 0.536	864	3.33 ± 0.66	865	2.76 ± 0.23
18	120 to 126	877	1.816 ± 0.507	875	3.43 ± 0.64	875	2.74 ± 0.24
19	127 to 133	744	1.965 ± 0.5617	742	3.27 ± 0.61	742	2.75 ± 0.19
20	134 to 140	710	1.839 ± 0.561	699	3.28 ± 0.56	699	2.72 ± 0.23
21	141 to 147	602	1.761 ± 0.515	583	3.44 ± 0.57	583	2.80 ± 0.22
22	148 to 154	814	1.794 ± 0.477	805	3.58 ± 0.56	805	2.77 ± 0.20
23	155 to 161	760	1.883 ± 0.538	753	3.35 ± 0.59	753	2.75 ± 0.20
24	162 to 168	682	1.650 ± 0.506	679	3.35 ± 0.56	679	2.75 ± 0.24
25	169 to 175	563	1.591 ± 0.546	546	3.42 ± 0.53	546	2.75 ± 0.23
26	176 to 182	1011	1.594 ± 0.420	996	3.50 ± 0.56	996	2.77 ± 0.22
27	183 to 189	704	1.565 ± 0.419	698	3.44 ± 0.63	698	2.87 ± 0.29
28	190 to 196	659	1.498 ± 0.451	652	3.43 ± 0.58	652	2.90 ± 0.29
29	197 to 203	716	1.440 ± 0.446	704	3.47 ± 0.64	704	2.93 ± 0.28
30	204 to 210	618	1.378 ± 0.411	600	3.59 ± 0.72	600	2.90 ± 0.29
31	211 to 217	369	1.446 ± 0.397	361	3.67 ± 0.58	361	3.00 ± 0.33
32	218 to 224	199	1.494 ± 0.390	198	3.67 ± 0.62	198	3.19 ± 0.64
33	225 to 231	66	1.177 ± 0.538	66	4.20 ± 1.41	66	4.36 ± 2.02
34	232 to 238	109	1.466 ± 0.353	108	3.96 ± 0.96	118	3.48 ± 0.90
35	239 to 244	65	1.459± 0.374	65	4.37 ± 0.83	65	3.48 ± 1.14
36	245 to 251	4	1.667 ± 0.456	4	4.90 ± 0.95	4	3.86 ± 2.40

N – number of observations, s – standard deviation

Table 2: Regression coefficients of lactation curves and goodness-of-fit for milk yield

Regression coefficients	Cubic	Ali-Schaeffer	Guo-Swalve	Wilmink
b_0	0.33685	11.92651	-0.79539	2.16785
b_1	0.03601	-14.28572	0.01855	-0.00320
b_2	-0.00025	3.71046	-0.00017	-3.4936
b_3	0.0000005	-6.18178	0.0000003	
b_4		0.89233	0.47026	
Statistical characteristics		Goodness-of-fit of the model		
R^2	0. 911	0.912	0. 915	0.842
RSD	0.0843	0.0859	0.0833	0.1102
Mean		1.590		
SD		0.2478		

R^2 – coefficient of determination, RSD – residual standard deviation, SD – standard deviation

Table 3: Regression coefficients of lactation curves and goodness-of-fit for fat content

Regression coefficients	Cubic	Ali-Schaeffer	Guo-Swalve	Wilmink
b_0	4.90121	-8.36509	8.41672	2.84866
b_1	-0.03359	15.07721	0.02064	4.42390
b_2	0.00019	-2.67597	-0.00007	0.00412
b_3	-0.0000003	7.61460	0.0000002	
b_4		-1.20193	-1.46013	
Statistical characteristics		Goodness-of-fit of the model		
R^2	0.670	0.699	0.691	0.600
RSD	0.2457	0.2385	0.2416	0.3594
Mean		3.605		
SD		0.5485		

R^2 – coefficient of determination, RSD – residual standard deviation, SD – standard deviation

Table 4: Regression coefficients of lactation curves and goodness-of-fit for protein content

Regression coefficients	Cubic	Ali-Schaeffer	Guo-Swalve	Wilmink
b_0	3.11615	18.04985	6.51895	2.24659
b_1	-0.00203	-25.41579	0.05453	2.57739
b_2	0.00005	11.39490	-0.00031	0.00450
b_3	0.0000003	-9.04542	0.0000008	
b_4		1.55180	-1.41332	
Statistical characteristics		Goodness-of-fit of the model		
R^2	0.713	0.709	0.710	0.426
RSD	0.1952	0.2062	0.2062	0.2797
Mean	2.940			
SD	0.3574			

R^2 – coefficient of determination, RSD – residual standard deviation, SD – standard deviation

as input data of all the models (in total, 518 557 test-day records were taken).

Lactation curves for milk yield, fat and protein content in goats of the White Shorthaired breed in Slovakia plotted on the base of the regression coefficients estimated by the considered models are given in Fig. 1, 2 and 3. The pattern of lactation curves was in accordance to the general pattern of goats (Ciappesoni *et al.*, 2004; Macciotta *et al.*, 2005; Waheed and Khan, 2013) and ewes (Cadavez *et al.*, 2006; Oravcová *et*

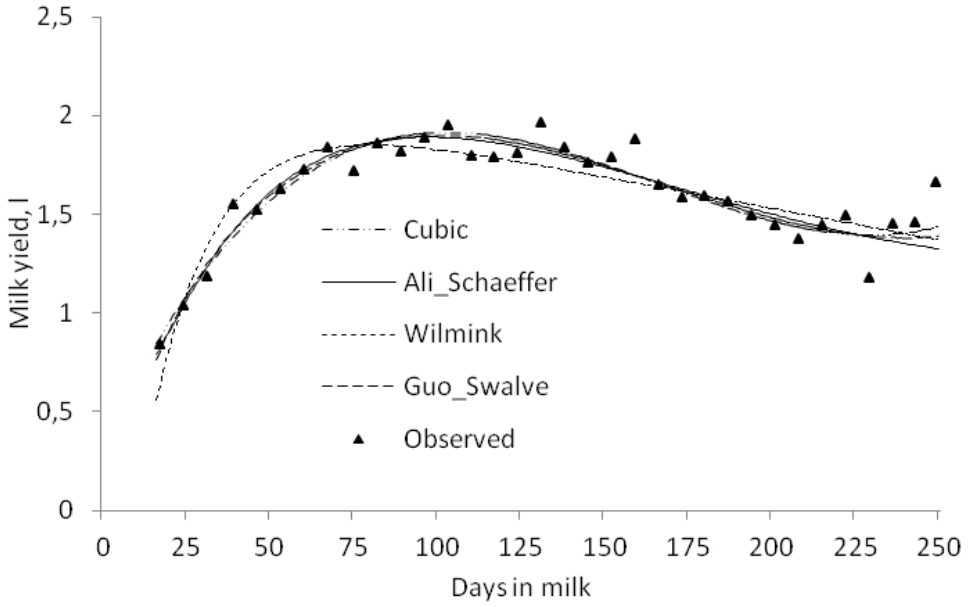

Fig. 1: Lactation curves for milk yield

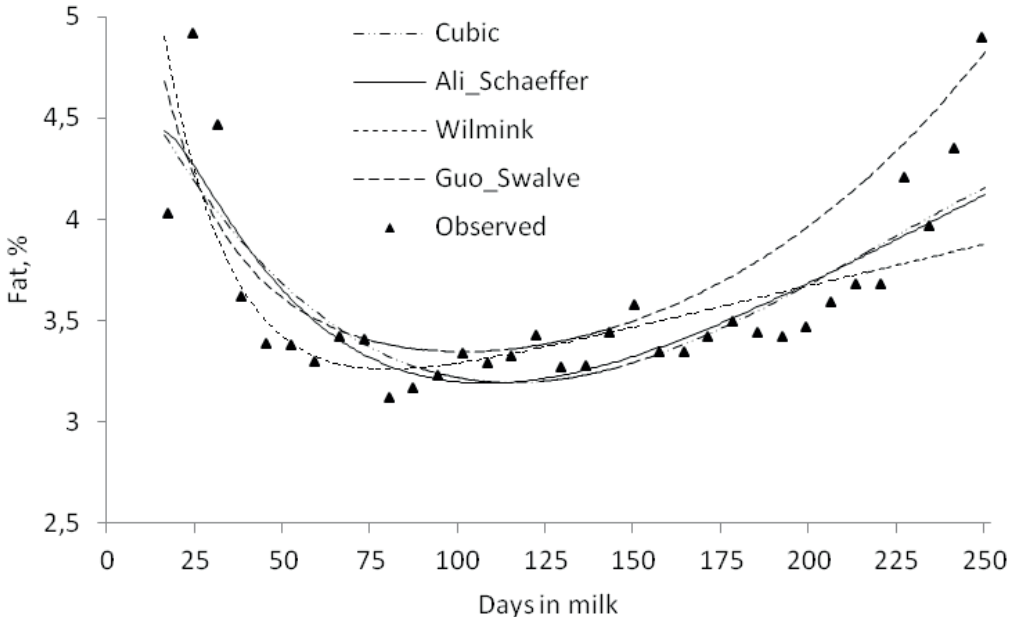

Fig. 2: Lactation curves for fat content

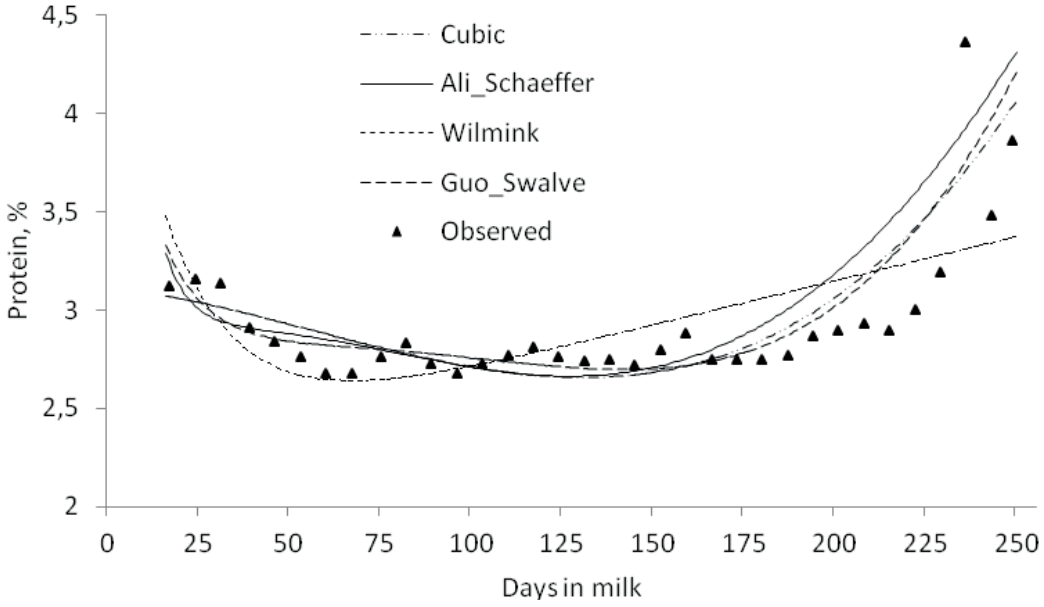

Fig. 3: Lactation curves for protein content

al., 2006 and 2007; Komprej *et al.*, 2012). Milk yield showed an increasing trend from 100 to 130 days in milk and decreased afterwards. At the end of lactation, only Cubic model showed sensitivity to the increase of milk yield (day 240 after parturition), the remaining models followed the decreasing trend of lactation curve (Fig. 1).When Quadratic model was fitted (not shown here), it was similar to Cubic model as far as the coefficient of determination and the residual standard deviation is concerned. The only difference was its insensitivity to the increase of milk yield in day 240 after parturition, the same as was shown by Ali-Schaeffer, Guo-Swalve (modified Khanderkar) and Wilmink models. Lactation curves for fat and protein content (Fig. 2 and 3) showed the opposite trend. These decreased from days 100 to 130 after parturition and increased afterwards. Cubic, Ali-Schaeffer and Guo-Swalve (modified Khanderkar) models were more similar to each other than to Wilmink model.

CONCLUSIONS

This study was the first attempt to estimate lactation curves for milk yield, fat and protein content in White Shorthaired goats in Slovakia. The course of lactation curves followed the pattern which is generally known for ruminants. No remarkable differences in the goodness-of-fit of the models were found (except for Wilmink model), therefore, Cubic, Ali-Schaeffer and Guo-Swalve (modified Khanderkar) models may support the belief that they seem to be useful for modelling of lactation curves in Slovak goats. Further research based on investigations of influence of individual days in milk during the course of lactation and study of effects such as parity, number of kids born, nutrition as well as rearing conditions in individual year and month in which monthly measurements were taken, is needed for better understanding of variation of milk traits in goats. The effect of individual doe is also not negligible.

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REFERENCES

AKPA, G.N. – ASIRIBO, E.O. – ONI, O.O. – ALAWA, J.P. 2001. The influence of non-genetic factors on the shape of lactation curves in Red Sokoto goats. *Animal Science*, 2001, 72, p. 233–239.

ALI, T.E. – SCHAEFFER, L.R. 1987. Accounting for covariances among test day milk yields in dairy cows.

Canadian Journal of Animal Science, 1987, 67, p. 637–644.

ÁNGEL MARÍN, P. A. – AGUDELO GÓMEZ, D. A. – RESTREPO, L.F. – CÁNAS ALVAREZ, J.J. – CERÓN-MUNOZ, M. F. 2009. Curvas de lactancia de cabras mestizas utilizando modelos matemáticos no lineáles. [Lactation curves in hybrid goats by the use of nonlinear mathematical models]. Revista lasallista de investigación, 2009, 6, p. 43–49 (in Spanish).

CADAVEZ, V.A. – SILVA, A. – MALOVRH, Š. – KOVAČ, M. 2006. Modelling lactation curves in dairy sheep rose under extensive production system. Proceeding of the 43rd Croatian and 3rd International Symposium on Agriculture, 2006, Opatija, p. 845–848.

CIAPPESONI, G. – PŘIBYL, J. – MILERSKI, M. – MAREŠ, V. 2004. Factors affecting goat milk yield and its composition. *Czech Journal of Animal Science*, 2004, 49, p. 465–473.

ICAR. 2003. International agreement of recording practices, 298 p.

GUO, Z. – SWALVE, H.H. 1995. Modelling of the lactation curves as a sub-model in the evaluation of test day records. Proceedings of the Interbull Annual Meeting, Prague, Czech Republic, September. 7–8. 1995, 4 p.

KOMPREJ, A. – GORJANC, G. – KOMPAN, D. – KOVAČ, M. 2012. Lactation curves for milk yield, fat and protein content in Slovenian dairy breeds. *Czech Journal of Animal Science*, 2012, 57, p. 231–239.

LEÓN, J.M. – MACCIOTTA, N.P.P. – GAMA, L.T. – BARBA, C. – DELGADO, J.V. 2012. Characterization of the lactation curve in Murciano-Granadina dairy goats. *Small Ruminant Research*, 2012, 107 (2), p. 76–84.

MACCIOTTA, N. – FRESI, P. – USAI, G. – CAPPIO-BORLINO, A. 2005. Lactation curves of Sarda breed goats estimated with test day models. *Journal of Dairy Research*, 2005, 72, p. 470–475.

MARGETÍN, M. – MILERSKI, M. 2000. The effect of nongenetic factors on milk yield and composition in goats of Shorthaired breed. *Czech Journal of Animal Science*, 2000, 45, p. 501–509.

ORAVCOVÁ,M.–MARGETÍN,M.–PEŠKOVIČOVÁ, D. – DAŇO, J. – MILERSKI, M. – HETÉNYI, L. – POLÁK, P. 2006. Factors affecting milk yield and ewe's lactation curves estimated with test-day models. *Czech Journal of Animal Science*, 2006, 51, p. 483–490.

ORAVCOVÁ,M.–MARGETÍN,M.–PEŠKOVIČOVÁ, D. – DAŇO, J. – MILERSKI, M. – HETÉNYI, L. – POLÁK, P. 2007. Factors affecting ewe's milk fat and protein content and relationships between milk yield and milk components. *Czech Journal of Animal Science*, 2007, 52, p. 189–198.

PALA, A. – SAVAS, T. 2005. Persistency within and between lactations in morning, evening and daily test day milk yield in dairy goats. Archiv Tierzucht, 2005, 48, p. 396–403.

SAS Institute Inc. *SAS/STAT ® 9.2User's Guide, Second Edition*, 2009. Cary, NC: SAS Institute Inc.

WAHEED, A. – KHAN, M. S. 2013. Lactation curve of Beetal goats in Pakistan. *Archiv Tierzucht*, 2013, 56. DOI: 10.7482/0003-9438-56-089.

WILMINK, J.B.M. 1987. Adjustment of test-day milk, fat and protein yield for age, season and stage of lactation. *Livestock Production Science*, 1987, 16, p. 335–348.